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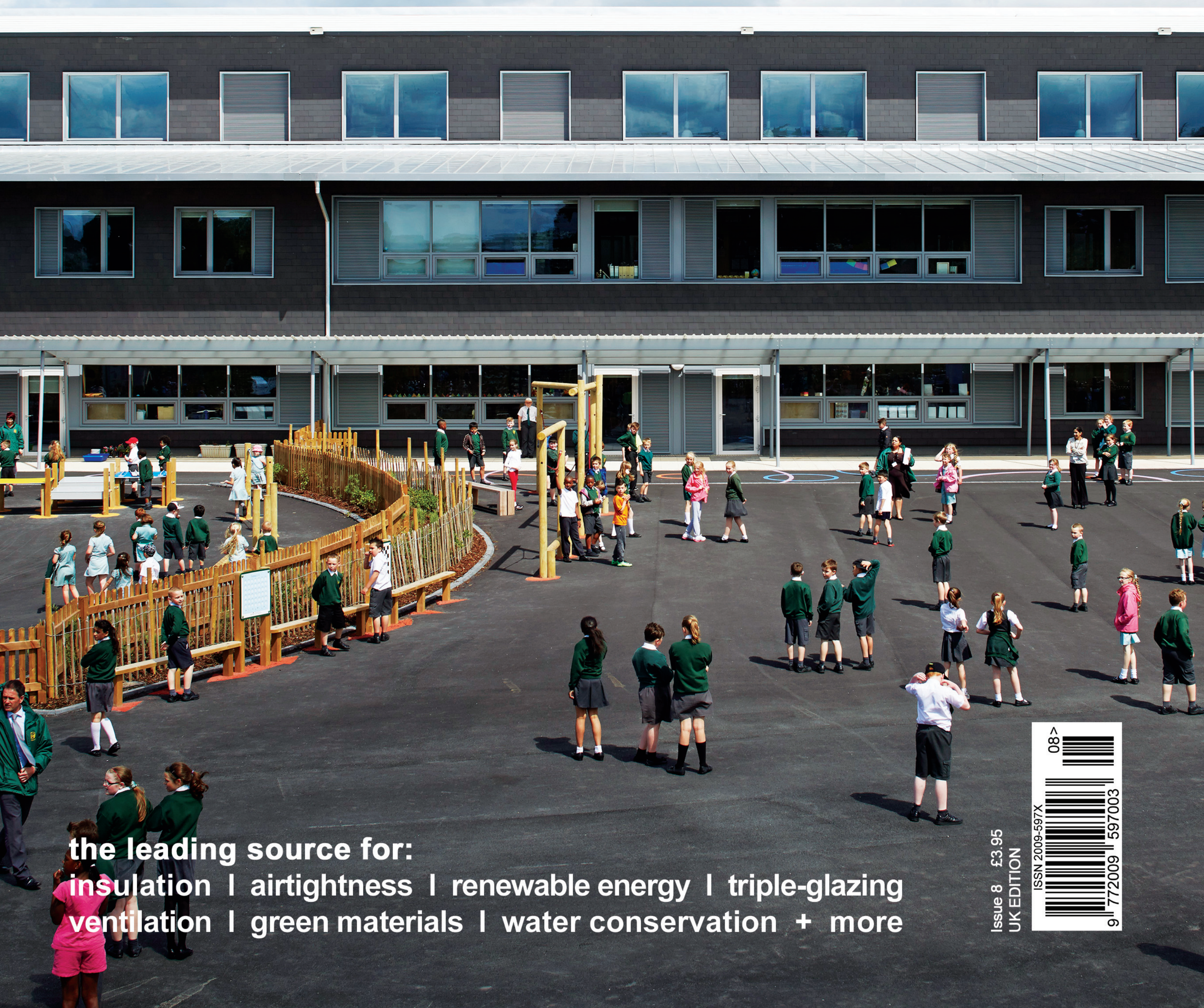

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# editor's letter

As this latest issue of Passive House Plus demonstrates, demand for passive house and for sustainable building in general is rapidly increasing in the UK and Ireland. But what's driving this demand – and what's motivating people to build better? Interestingly, it appears that the answer to this question may be different on either side of the Irish sea.

Traditionally, attention to sustainability and better build quality in general has tended to come from the likes of self-builders and public sector clients, as well as voluntary housing providers – basically everyone except speculative developers. The common denominator is an interest in build quality that endures long beyond completion. This is as heartening as it is logical: it tells us that private landlords aside, developers who retain ownership of a building – and therefore stand to either occupy it or to have an ongoing engagement with its occupants – are more likely to think about sustainability. This may suggest that the public is warming to sustainable building, and that progress has been held back by market failures, with speculative developers broadly failing to deliver sustainable buildings, lenders failing to recognise the investability of sustainable buildings, and a consequent failure to give buyers and tenants the ability to vote with their feet.

That said, the industry is being forced to up its game on energy efficiency specifically, albeit to different extents. Changes to the Irish version of Part L for homes – which I'm proud to have helped bring about in spite of my longstanding concerns over some of the finer points in the technical guidance documents – require a whopping 60% reduction in energy demand compared to 2005 standards. The UK's changes are less pronounced, particularly in England, where the new version of Part L for homes only requires a 6% carbon reduction. Admittedly the UK government is still pledging to make all new homes zero carbon by 2016 – a highly questionable target given the proposal to include creative accounting in the form of carbon offsetting, alongside some fabric improvements and renewable energy generation.

But the fact remains that in terms of building anywhere close to passive house levels of energy efficiency, building regulations are not yet a driver in the UK. Consequently, the burgeoning passive house sector is being driven by clients who sign up voluntarily. To the extent that there are enough of these enlightened clients about, this is a fantastic way to grow a sector. The focus is on performance, quality and value, rather than just price. Clients like this do exist in Ireland, as the Irish case studies in this magazine demonstrate, issue after issue. But as with the UK, traditionally they've only been a fraction of the overall market.

Ireland is now in unchartered waters –and the UK must eventually follow as its own regulations improve – in that anyone building a new home has to deliver an ultra low energy home, on paper at least. This means the market isn't just a motivated minority. It's anyone who's building, and that includes some people who will seek to comply as cheaply as possible, irrespective of quality.

There are significant question marks over some of the ill-conceived compliance approaches that a client governed by price and habit rather than performance may choose. The right solutions are out there, as the excellent buildings featured in these pages demonstrate, but only time will tell whether those clients who see price rather than value choose to adopt them.

Regards,
the editor

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iPHA

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2012 Business magazine of the year
- Irish Magazine Awards

Jeff Colley: winner green leader award
-Green Awards 2010

Construct Ireland: winner green communications award
-Green Awards 2010


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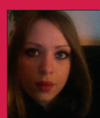
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**Cover: Wilkinson School**
**Photograph: Dennis Gilbert**


ABC Certified Average Net Circulation of 9,621 for the period 01/01/13 to 30/06/13

# contents




22


30


36


40


62


66

# News

## PH+ audit reveals strong Irish & UK circulation


Passive House Plus magazine continues to have the highest circulation of any construction magazine in Ireland, and to be the country's only building magazine with independently audited circulation.

According to our latest ABC figures, the Irish edition of the magazine's average net circulation from 1 July 2012 to 30 June 2013 was 6,272. The UK edition is now audited too, with an average circulation per issue of 9,621 for 1 Jan to June 2013. The combined total of 15,893 is higher than the latest ABC audited average circulation for world-famous music magazine NME.

But these figures are a conservative estimate of the magazine's circulation, due to a combination of ABC's strict reporting rules and the omission of the digital editions of Passive House Plus. ABC's rules mean that copies which were not part of the main bulk mailing runs — such as 1000 copies circulated at Ecobuild in March 2013 or any copies sent individually or in bulk from the magazine's offices — cannot be counted. Although both Irish and UK editions are also available in print and digital form, the ABC certificates for Passive House Plus only count print copies.

The UK edition is distributed by targeted circulation through members of the AECB, the Passivhaus Trust, Green Register, and to individuals involved with live construction projects through Glenigan's project database.

"We're delighted to have so many readers engaging with the magazine, as the vast number of enquiries we get from readers bears testament. We're amazed that so many designers, clients and contractors continue to send us enquiries about real low energy buildings that they're planning to build." said Passive House Plus publisher and editor Jeff Colley."

Passive House Plus was born in 2012, with the rebranding of the influential Irish sustainable building periodical Construct Ireland. The UK edition launched early in 2013.

(left) The first issue of Passive House Plus at the printers

## UK Passivhaus Conference just around the corner

The 2014 UK Passivhaus Conference and Exhibition will be held on Thursday 16 October at the Stevenage Arts and Leisure Centre, providing the latest information about passive house in the UK.

The conference will explore how the passive house standard can be used to help deliver near and zero energy buildings. It will include leading-edge project presentations, detailed project case studies and networking sessions to bring participants up-to-date with all the latest research and practice. It will present new discoveries from the latest academic and industry research, and feature an innovative exhibition of passive house specific products and services.

The conference will include leading speakers from the UK and across Europe, including Brussels-based architect Sebastian Moreno-Vacca, who will talk about the city's adoption of the passive house standard, and Jessica Grove-Smith from the Passive House Institute, who will discuss the role of passive house in delivering near zero energy buildings.

The conference is targeted at construction and built environment disciplines ranging from architects, planners, building control officers, energy managers, builders, housing associations and researchers.

For further information, go to:
**www.ukpassivhausconference.org.uk**
Passive House Plus is a media partner for the event.

## Stirley Farm picks up green building gong

Photo: Green Building Store

Green Building Store picked up the 'Legacy Award — Sustainability' at this year's Constructing Excellence Yorkshire & Humber Awards for its Cre8 Barn project at Stirley Community Farm.

This retrofit for the Yorkshire Wildlife Trust featured in issue seven of Passive House Plus.

The pioneering low energy refurbishment has transformed a derelict cow barn into an eco-exemplar educational centre and space. The project has been designed to Enerphit, the Passive House Institute's retrofit standard.

A super-insulated timber frame structure was built inside the existing stone barn building, preserving the outward appearance of the barn, while ensuring high levels of airtightness and continuous insulation. The timber frame structure has the additional advantage of supporting and shoring up the original stone building.

The awards were announced on Friday 18 July at a ceremony at Sheffield City Hall and all winners are entered into the National Constructing Excellence Awards on Friday 14 November in London.

Green Building Store director Chris Herring commented: "It is fantastic that the Cre8 Barn project has received recognition in this way. The project has demonstrated innovative solutions to the challenges of bringing older buildings up to 21st century energy efficiency levels. We applaud our clients Yorkshire Wildlife Trust for their vision and foresight in embracing the passive house 'fabric first' approach to low energy building."

(above) The Cre8 Barn at Stirley Community Farm has picked up a sustainability award at the Constructing Excellence Yorkshire & Humber Awards

# News

## Munster Joinery awarded BBA cert for alu-clad triple-glazed window

Munster Joinery Ltd has achieved BBA certification for its Passiv AluClad composite window system. This is the first composite system of its type to achieve BBA approval. The system consists of two frames made from different materials — the external one is powder-coated aluminium and the internal is made of laminated timber. A PVC-U channel filled with insulating foam links the two frames together and is designed to eliminate thermal bridging at all critical points.

Passiv AluClad windows are double or triple-glazed with multiple panes of low emissivity glass and optimum cavity widths filled with a low conductivity gas such as argon or krypton. A warm edge spacer bar reduces edge losses to a minimum.

The triple-glazed window was recently used in a social housing development by the Sustainable Design Collective for South Devon Housing Association. The clear varnished internal finish gives the aesthetic advantages and warmth of a natural wooden window. The external aluminium frame gives the structural strength, corrosion resistance, durability and recyclability of aluminium and comes in a range of RAL colours to allow flexibility of design.

"The window is designed to meet the demands of the passive house standard. Windows are a huge part of any passive build and performance, affordability and versatility are key criteria," said Marlene O'Mahony of Munster Joinery.

(above) Munster Joinery's Passiv Aluclad composite windows were used in the Sustainable Design Collective's social housing scheme for South Devon Housing Association

## Schöck cuts thermal bridges at passive Camden scheme

Schöck Isokorb thermal break technology has been employed at the Chester Balmore passive house development in Camden to eliminate thermal bridging at balconies.

Chester Balmore is part of Camden Council's community investment programme and is said to be the UK's largest passive house residential scheme to date. Rick Mather Architects designed the project, which consists of 53 new homes, a GP surgery and shops, all set around a landscaped courtyard.

Schöck Isokorb not only thermally separates components from one another, to eliminate thermal bridging, but also acts in a structural design capacity as well. At Chester Balmore, the latest generation Schöck Isokorb XT — for concrete to concrete applications — was specified. The product is certified by the Passive House Institute.

The principle reason for the superior performance of the XT is the thickness of the insulation body, which is increased from 80mm to 120mm. The XT not only improves thermal insulation performance by up to 30% in comparison to the standard range, it also improves impact sound insulation by around 50% as well. High quality stainless steel bars with improved tensile strength is an integral part of the unit and while the same load-bearing capacity is maintained, there is a smaller rod diameter and therefore a reduction in the thermally conducting cross-section, resulting in a further increase in the heat insulation performance.

Tim Paul from Rick Mather Architects said: "Balconies offer practical and aesthetic advantages for residents, but they have not always been a popular choice in the context of high efficiency passive house design. However, the advanced technology and superior performance of the Schöck Isokorb XT range offers such a high level of insulation, that we had no problem in incorporating balcony design into the Chester Balmore project."

The Isokorb range enables connections to be made between concrete-to-concrete, concrete-to-steel and steel-to-steel – and the many different unit types available, combined with their ability to enable the transmission of shear, bending moment, tension and compression forces, also means that the options available effectively run into hundreds when the different combinations are taken into account. All units provide BBA Certification and LABC Registration and meet full compliance with the relevant UK building regulations.

(above) Schöck Isokorb was used to prevent cold bridging at balconies in Chester Balmore

# News

## Partel launches insulation, ventilation & airtightness products

Partel has launched a range of specialist insulation, ventilation, and airtightness systems to the UK market, aimed at the low energy building sector.

Partel is the exclusive Irish and UK agent for the Ampack range of airtightness, windtightness, and building protection products. Founded in 1946, Ampack is one of Europe's most established specialist membrane and tape manufacturers. "Our Ampack products offer a complete building protection system, from radon membranes to airtight membranes, tapes, adhesives, and windtight membranes, and Ampack's unique 10 year guarantee ensures customers confidence in our range," said Hugh Whiriskey, who founded Partel in 2011.

Partel also supplies the Lunos range of humidity-activated decentralised ventilation systems, including the award-winning Lunos e2, one of the smallest heat recovery ventilation units in the world. The Lunos e2 is not only duct free but can be used in both new and retrofit construction. Whiriskey said the long life filters and low running cost of Lunos systems mean customers can have a premium system with minimal running costs.

In addition, Partel offers the Schneider range of woodfibre insulation. "Schneider woodfibre is produced in one of the most modern factories in the world; the quality of the products is unparalleled," Whiriskey said. "Amazingly, they have a zero waste production plant." The woodfibre is produced from the by-products of timber production, and waste from the insulation manufacturing process produces biomass that powers the plant.

Partel has also partnered with Episat to bring the Epatherm range of calcium silicate insulation boards, for use primarily in older buildings, to the UK.

Whiriskey said: "As an engineer with 15 years experience in construction I've found that there's a demand for higher quality building products, and that the focus will continue to move towards natural and sustainable products. We offer customised technical sales and provide support on all of our products from specification advice, Wufi analysis, training, and onsite inspections. We believe we have a lot to offer to the modern builder.

Whiriskey said that in addition to low energy buildings the company have a number of passive house and Enerphit projects on their books. "We believe this is a reflection of the quality of our products and services," he said.

(pictured) The Lunos e2 single room MVHR system and Ampatex Variano, part of the Ampack range, available in the UK via Partel

## Passivhaus Trust announces UK award winners

Photo: Leo Wilkinson Photography

The winners of this year's UK Passivhaus Trust awards were announced at a ceremony in London on 1 July, 2014. The Saint-Gobain sponsored awards recognise the best passive-certified building projects in the UK.

Parsons & Whittley Architects picked up the Munster Joinery sponsored Architectural Design award for their Burnham Overy Staithe three-house terrace in an area of outstanding natural beauty in Norfolk. The houses, a mix of affordable and open-market units, are designed to reflect the local "fisherman's cottage" vernacular. The other nominees were Hindolvestone Road affordable housing in Norfolk, by Mole Architects, and Standings Court social housing in West Sussex, by MH Architects.

Meanwhile Kirsty Maguire Architects picked up the Ecology sponsored award for Bespoke Projects Design for her barn-inspired farmhouse in Ayrshire on the west coast of Scotland. The house was previously featured in issue six of Passive House Plus. Also nominated was the River Studio in Warwickshire by Sjolander de Cruz Architects, and Stories Mews mixed living and office space in Camberwell, London by Richard Dudzicki Associates Ltd.

Beattie Passive, Encraft and Force picked up the Saint-Gobain sponsored Cost and Buildability award for their Coventry Eco House project, a development of two detached red brick homes that aimed to engage the local supply chain in building to the passive house standard. The other nominees were the Crawfordsburn private dwelling in Northern Ireland, by Paul McAllister Architects, and the Hart Lea affordable housing scheme in Derbyshire, also by Encraft.

More details on the winners and all of the nominated projects are available at www.passivhaustrust.org.uk The judging panel was comprised of Nick Grant and Kym Mead of the Passivhaus Trust, Mark Gillott of Nottingham University, Hattie Hartman of the Architect's Journal and Bill Butcher from the Green Building Store.

(left) Members of the teams behind the 2014 UK Passivhaus Awards winning projects

# News

## Advantage Austria announce CPD event for Edinburgh

Advantage Austria has announced the date for its next CPD oriented presentation and networking event on passive house and low carbon building.

Following the success of a similar event in London in June, the next event will take place at Edinburgh's Napier University on 2 October. Speakers will once again include Conor Ryan from window manufacturer Optiwin and Stuart Prause from airtight and windtightness solutions manufacturer Isocell.

Also presenting will be the award winning Scottish architect Kirsty Maguire, who recently scooped a UK Passivhaus Award for best bespoke project for her passive farmhouse in Ayrshire, featuring Optiwin windows.

With the continuing growth in interest in low energy building in the UK, as well as a stricter regulatory framework, there is a need to further develop the supply chain for low energy building technology. According to Peter Franklin at Advantage Austria in London: "For Austrian companies who have long experience in developing low carbon technology in central European markets, the main issue in the UK market is finding the right supply partners. We urge anyone in the UK supply chain interested in partnering with Austrian technology companies to contact us."

Conor Ryan commented: "We are delighted to be teaming up again with Advantage Austria to offer this CPD oriented seminar in Scotland. There was a very positive resonance from the event in London and we are pleased to be able to help promote low energy building in Scotland."

Anyone wishing to register their interest in this event should contact Peter Franklin at London@advantageaustria.org.

(above) Optiwin's Conor Ryan speaking at an Advantage Austria event in London in June on passive house and low carbon building

## ICF growing in popularity — Leathwaite

Demand for insulating concrete formwork (ICF) as a building method has increased recently, according to specialist ICF contractor Leathwaite. The company said several factors are leading architects and clients to consider ICF for their projects.

Leathwaite technical director, Corté Ray-Iliffe has been building with ICF in the UK for 14 years, and while the wider industry has been slow to adopt ICF as a build method, he said that it has many advantages over other methods.

"With regards to building performance we see excellent correlation between design stage assessments and the long term real life performance of ICF structures. The longevity of the monolithic concrete core, which has advantages when trying to achieve airtightness and sound testing, is a major benefit. Many of the early adopters of ICF were self-builders and if you speak to people living in ICF houses they really love them.

"The thickness of EPS insulation can be increased to achieve whatever target U-value is needed for the overall performance of the building," Corté said. "With a total wall thickness of 450mm, including internal and external finish, we can achieve 0.10 W/m$^2$K. And below that it is simply a trade-off between performance and wall thickness."

The combination of ICF and insulated foundations is also a key factor in achieving performance standards. "An EPS based foundation system can be designed easily to integrate with ICF walls to address thermal bridging," he said.

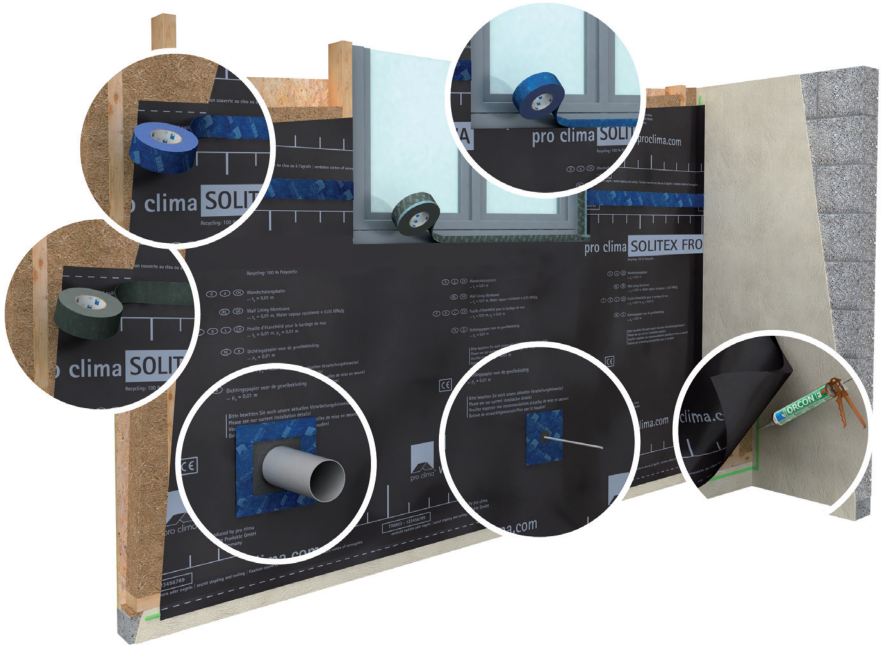
ICF offers more design flexibility than some realise and can be used to create straight, angled or curved walls, he said, and can be used above or below ground. Corté explained: "We are seeing more projects that include a basement or below ground elements as architects look to maximise the available space. With ICF you can increase the concrete core size and reinforcement for below ground, making ICF an ideal solution structurally, and to deal with the waterproofing issue we use integral crystalline waterproofing for the concrete core."

There are other developments in technology around the ICF industry which are also impacting on its popularity, Corté explained. "We are seeing new complimentary products that are helping make ICF an even more attractive solution, for example a new low carbon concrete which utilises ground blast furnace slag (GGBS) as a replacement for Portland cement (OPC) and a new external brick cladding system designed specifically for ICF."

(above) Leathwaite's Dunedin Mews project won the best small development award at the 2012 London Evening Standard New Homes Awards

# News

## Pro Clima launches new high performance membranes



Ecological Building Systems has announced the launch of the new range of Pro Clima Solitex Fronta high performance, windtight diffusion-open wall lining membranes. The range comprises Solitex Fronta WA, Solitex Fronta Humida and Solitex Fronta Quattro.

Unlike conventional microporous wall lining membranes, the range features Pro Clima's unique closed-cell, air-impermeable yet highly vapour-permeable technology. This ensures exceptional windtightness and water-tightness is attained without compromising the ability for timber structures to permit optimum vapour diffusion.

Solitex Fronta WA is suitable for use behind close-jointed façades while Solitex Fronta Quattro, which features a UV stable layer, is for use behind open-jointed facades. Quattro features a black membrane and black print, concealing it behind an open-jointed façade. Quattro carries CE marking, certifying full conformity with the EU's Construction Products Directive. To obtain the CE marking for open cladding use, Quattro had to resist 5000 hours of permanent UV radiation. Pro Clima also supply a black tape, Tescon Invis, to further conceal taped joints behind open façades.

Solitex Fronta Humida is specifically designed for use in conjunction with woodfibre insulation such as Gutex behind masonry façades. Each of the Fronta membranes is also available with a pre-applied Pro Clima Connect tape.

Niall Crosson, technical engineer with Ecological said: "The negative impact and increased heat losses associated with thermal bypass and air infiltration are now more clearly recognised. The new range of Pro Clima Solitex Fronta membranes along with high performance Pro Clima tapes and seals, ensures optimal levels of windtightness are attained combined with high levels of vapour permeability and water tightness. This is critical in the exposed and damp climate we experience in Ireland and the UK."

The company, who offer help to guide building professionals through design detailing, products and advice on installation, provide an RIAI accredited CPD presentation which carries 2 CPD credits , as well as practical and technical training at their Better Building: Fabric First course. Further details are available on www.ecologicalbuildingsystems.com

(above) The Solitex Fronta WA membrane, one of the latest additions to Pro Clima's high performance building fabric solutions

## TeploTie range extends to surface fixing

Masonry fixings specialist Ancon is continuing to lead the market in low thermal conductivity wall ties, with an "innovative" extension to its award-winning TeploTie range that is suitable for surface fixing to an in-situ masonry leaf or structural frame. TeploTie is distributed in Ireland via Longs.

Like the original TeploTie cavity wall tie, launched by Ancon in 2009, the new Teplo-L-Tie comprises a pultruded basalt fibre body set in a resin matrix. This material, with a thermal conductivity of just 0.7W/mK, minimises heat loss across an insulated wall cavity, which is an essential consideration in low energy construction.

Unique to the new Ancon Teplo-L-Tie, however, is an L-shaped stainless steel upstand, mechanically and chemically bonded to one end, which allows it to be securely tied to steel, timber, concrete or masonry using a range of standard fixings. Available to suit cavity widths up to 300mm, Ancon said it is ideal for today's super-insulated building envelopes.

To aid those performing U-value calculations, this new composite wall tie has been thermally modelled by an industry expert, allowing Ancon to provide accurate Chi values for each product length. Ancon said that the exceptional thermal efficiency of the TeploTie range, however, is such that it is unlikely ever to be taken into account in these calculations as a thermal bridge, minimising insulation depth and wall footprint.

The launch of the new Teplo-L-Tie coincides with further developments in the standard TeploTie range which is now available for an even greater range of cavity widths up to 450mm.

Ancon marketing manager Annabelle Wilson said of the latest product launch:"Ancon is constantly working at the leading edge of thermally efficient building design, and low thermal conductivity wall ties are a great example of this. Although the Teplo-L-Tie will be new to many in the industry, it has already been used successfully in a number of high specification residential and commercial developments, in both the new-build and refurbishment sectors, by those who specialise in ultra-low energy construction."

(above) Ancon's new Teplo-L-Tie has added to the company's range of thermal breaks

# News

## Quality installation key for window airtightness — Janex

Choosing a window company that provides a complete supply and install package provides a big advantage when it comes to airtightness, according to Norwegian window firm Janex.

Current UK building regulations allow for leaky construction, with an air permeability rate of 10m³/m²/hr under pressure test conditions. But to achieve code levels four, five and six, and the passive house standard – with a pressure test target of 0.6 air changes per hour, which in a typical dwelling would translate to a permeability close to 0.6m³/hr/m² – airtightness needs to improve dramatically.

"The industry has external envelope products that meet or exceed these requirements, but the challenge is to ensure robust installation detailing," said Brian Davie of Janex. "The higher code ratings can only be achieved if proper design solutions and installation are adopted."

"The industry standard is to buy window and door products from a manufacturer and employ an external subcontractor to install them, making it difficult to control the quality of the installation. Janex is one of the few window companies to take a different approach, providing a complete supply and install package. Our 'hot box' testing has shown how the inclusion of a third airtight internal seal is necessary to reach passive house airtightness requirements, and our service package means we take full responsibility for installation standards as well as for the design and manufacture of the windows and doors."

Main Photo: Neil Phillips Photography

Bath University recently chose Janex windows and doors for its HemPod experimental building. In airtightness tests carried out by Building Analysis and Testing Ltd, they contributed to an impressive airtightness result of 0.55 m³/hr/m². Meanwhile, London-based HTA Architects, and Barratt Developments chose Janex windows and doors for Hanham Hall, which is claimed to be the UK's first large-scale residential development built to code six, the highest level of the Code for Sustainable Homes.

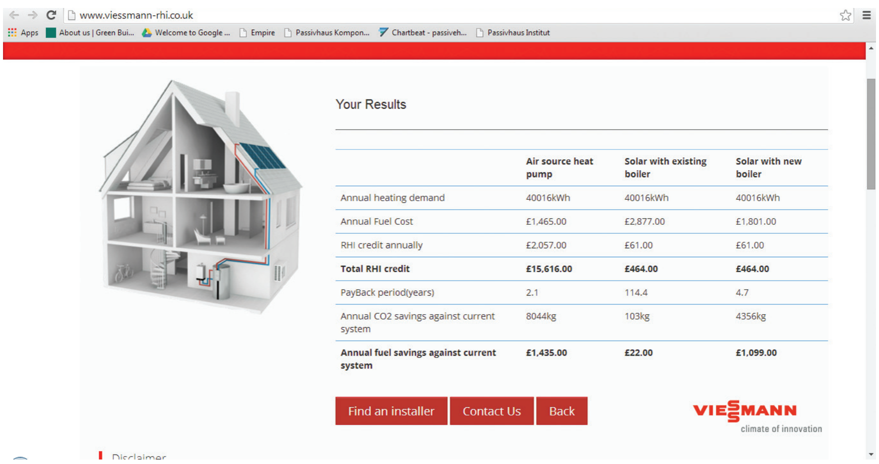
Janex installed high performance timber windows and balcony doors, as well as composite entrance doors, with whole product U-values ranging from 1.4 W/m²K to 0.84 W/m²K. Janex said the products complied with Lifetime Homes and Secured by Design and formed part of an airtight construction.

(above) Janex windows and doors have been selected for the Hanham Hall scheme and (inset) the University of Bath's HemPod experimental building

## Viessmann launches online renewables calculator

Viessman has launched an online calculator to work out the most appropriate renewable technology for different homes, in light of the introduction of the government's domestic renewable heat incentive (RHI), which offers long term financial support for the generation of renewable heat in the home.

The scheme is designed to increase the uptake of renewable technologies in the home and reduce the domestic carbon footprint in the UK. Viessmann's calculator is available via www.viessmann-rhi.co.uk and takes just seconds to work out the calculated savings, after users enter their postcode, property type and age, floor area, number of occupants and the age and type of the current heating system. Using this information, the easy-to-use interface then displays the results, allowing you to compare technologies to provide the best savings for your home. The results include the total RHI credit, the payback period and the annual $CO_2$ and fuel savings compared to the current system.




Darren McMahon, marketing director at Viessmann said: "Consumers hear about lots of government incentives for reducing energy consumption on the news and feel that the ins and outs of the schemes can be difficult and confusing to navigate. Viessmann's domestic RHI calculator will allow homeowners to look at different options in a clear and concise way, encourage them to invest in the lower long-term running costs that renewable technologies offer and significantly reduce their own carbon footprints."

The technologies the domestic RHI covers include biomass, solar thermal, and ground air source heat pumps.

# News

## ScreedBoard picks up Housebuilder gong

Cellecta recently picked up the award for best interior product at the 2014 Housebuilder Product Awards. The awards recognise the best new and innovative products in the industry.

ScreedBoard is a low profile, dry screed gypsum-based floor board manufactured from 100% recyclable material that features a unique interlocking edge detail that avoids the use of screws. Cellecta said that ScreedBoard's thermal resistance of just 0.05 m²k/W allows underfloor heating to spread evenly through the floor and provide occupants with optimal warmth underfoot. ScreedBoard typically increases heat efficiency by 30 to 40% when compared to timber overlays, Cellecta's Richard Hillman told Passive House Plus.

When installed as an acoustic system on a separating floor, ScreedBoard is designed to deliver excellent sound proofing performance.

"Compared to traditional acoustic batten systems that require four individual components, ScreedBoard is super slim and involves only two components for successful installation – the board and the acoustic edge strip," Hillman said. "This significantly speeds up build times and typically saves a course of bricks per storey, reducing the height of the roof ridge." Typical acoustic performance when installed as an E-FT-5 system is 51dB Airborne and 55dB Impact, exceeding the Part E Building Regulation requirements.

Hillman said the boards are ideal for new build and refurbishment projects due to their extensive benefits and all round versatility, with their unique lay and lock screwless edge detail making it quick and simple to install a high density, ultra performance floor with a screed look finish. "Other similar systems need to be screwed down, representing significant increases in cost and time" he said, adding that this method of installation also creates the potential for damage to be inflicted to the underfloor heating systems, which would require extensive remedial work post floor completion.

Once ScreedBoard is installed carpet and laminate flooring can be applied directly to finish the floor. Hillman said the boards excel in bathroom and kitchen areas as ceramic tiles can be installed directly, offering a significant benefit over traditional chipboard. "As a dry screed solution ScreedBoard removes the drying times that are typically associated with wet screed, considerably reducing overall build times and reducing the impact on the overall floor height," he said. The boards are suitable for ground floor applications where underfloor heating is required, on a separating floor for soundproofing or as a combined under floor heating and soundproofing solution.

(above) Cellecta's ScreedBoard gypsum-based floor board system

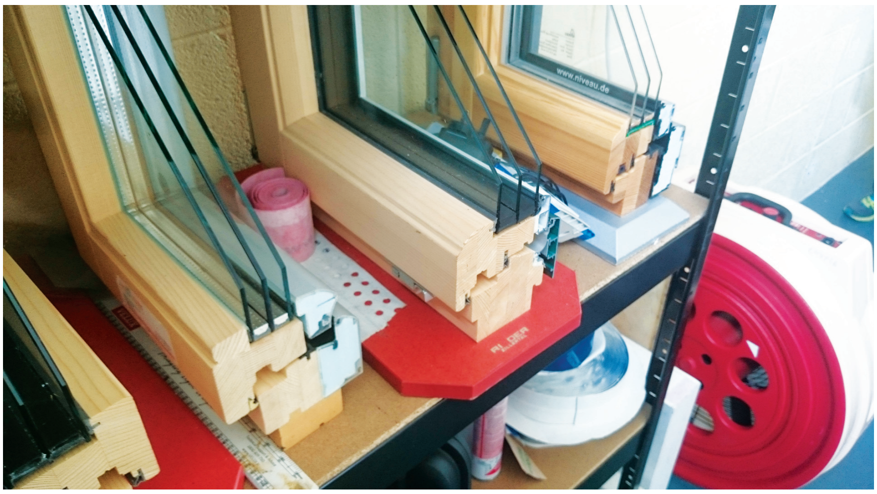
## Target Zero to open passive training centre for public

Passive house training provider and consultancy Target Zero has announced that it will open its training centre at the Institute of Technology, Carlow to the public from September. "Here you can see a number of passive house window sections, various wall build-ups, certified MVHR units, insulation and airtightness products," said Target Zero's Darren O'Gorman.

Target Zero has also announced that 24 newly qualified passive house designers and consultants qualified from its latest exam, held on 6 Jun, with participants coming from Ireland, the UK, Norway, Spain and Czech Republic. The company is planning to run a passive house designer course in London this October, and further passive house tradesperson courses this November in Bristol, Surrey and at their centre in Carlow. Separate courses are also offered including MVHR installation, an airtightness installer's course and a software course covering the new Sketchup DesignPH plugin.

Full details are available at www.targetzero.ie and www.passivehousetraining.co.uk. Courses run regularly throughout the year in the UK and Ireland. Those looking to visit can make an appointment by email.

Target Zero is also currently providing consultancy on various passive house projects, including: a subterranean passive house in Donegal, new building passive homes in Carlow, Kildare, Galway, Antrim and Manchester.



(left) Target Zero's IT Carlow-based training centre, which includes a range of samples of passive house components and build-ups, is now open to the public

# News

## Mapei flooring featured at 'Britain's greenest service station'

Photo: Edward Shaw

A Mapei decorative floor system has been installed at Gloucester Services – a new environmentally-friendly service station on the edge of the Cotswolds.

Located on the M5 Northbound, between junctions 11a and 12, 'Britain's greenest motorway services' was delivered by AFL Architects. The main building is constructed from local stone and timber, and features an arched grass-covered roof. The building is set to receive a Breeam excellent rating.

Three individual Mapei products were specified, alongside porcelain tiles and vinyl sheeting, throughout a 1,236 sqm area. All floor works were carried out by Polished Concrete Designs for main contractor, Buckingham Group Contracting Ltd.

Gloucester Services, which opened in May, is a £40 million joint project between a local charity and Westmorland Limited. The charity, Gloucestershire Gateway Trust, will generate income from the service station, to support nearby target communities and charity partners in Gloucester and Stonehouse. The site includes extensive landscaping, along with electrical vehicle charging stations, a wildflower seeded roof and capacity to switch to bio-fuel pumps. A farm-shop will also feature at the site, stocked with local produce, in place of fast food outlets.

Within the main building, a screed incorporating Mapei's fast drying hydraulic binder, Topcem, was laid over insulation and underfloor heating. Mapei's two-component, solvent-free Primer SN was applied to provide a key for Mapei Ultratop, a decorative anthracite-toned surface that gives the appearance of polished concrete. The petrol station was also completed using Mapei Ultratop Anthracite.

(above) A Mapei decorative floor system including an anthracite-toned surface that gives the appearance of polished concrete was installed at Gloucester Services

## 11-storey Enerphit breaks ground in Portsmouth

The retrofit of Wilmcote House, an 11-storey tower block in Portsmouth, has just broken ground. The deep-green refurbishment project, designed to meet the Enerphit standard, will deliver 111 homes that meet UK Government carbon reduction targets for 2050. Selected by the Passive House Institute as the UK case study for the Europe-wide Europhit project, which aims for an energy revolution in the refurbishment of existing buildings, the upgrade will result in energy savings of approximately 90%.

The building is owned and managed by Portsmouth City Council and the massive energy savings will address the serious fuel poverty issues experienced by residents, many of whom are unable to adequately heat their homes. The project – which is covered in more detail in a feature article on page 70 of this issue – will also resolve the ongoing maintenance issues with the building and create a new thermal envelope which effectively insulates residents against future energy price rises and significantly extends the lifespan of the building.

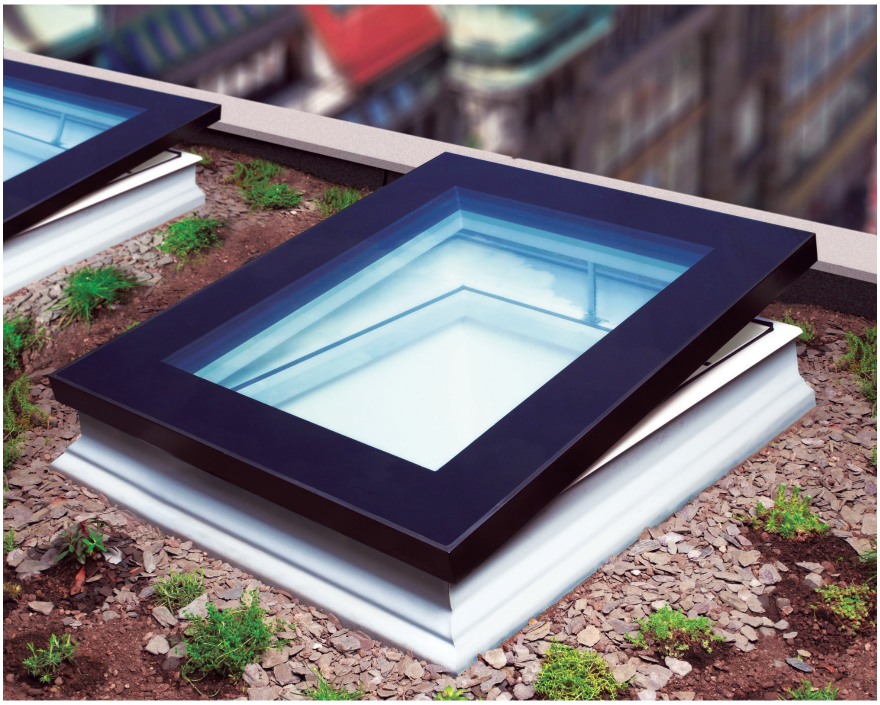
Ongoing maintenance issues with the building had led Portsmouth City Council to consider demolition, but given the scale of relocation costs it quickly became clear that refurbishment was the only practical and cost-effective solution. ECD Architects were therefore appointed in 2012 to investigate options for over-cladding and refurbishment. The team quickly identified the potential for a deep-green long-term solution and proved the long term financial payback (15 years) against standard over-cladding measures. Keepmoat was appointed as contractor in January 2014, and the works are scheduled to be completed by October 2016, with ongoing monitoring thereafter. The intensive nature of the works has required very careful coordination to minimise disruption for existing residents.

Portsmouth City Council are partnering with research organisations including LSE (funded by Rockwool). Southampton University and Portsmouth University to monitor the building and better understand the benefits – including health, social and financial aspects – arising from this level of refurbishment.

(above) Wilmcote House in Portsmouth, where an Enerphit upgrade project has started on site

# News

## Fakro urge focus on installed U-value & airtightness



Fakro has announced that it has achieved an installed U-value for its quadruple-glazed FTT U8 Thermo of 0.58. The company also said this glazing unit is available as part of its newly launched flat roof DEF window range. In addition to providing a contemporary option for a flat roof conversion, Fakro said the DEF window set within an upstand is ideal for greens roofs too.

“With increasing acknowledgement of the part that roof windows play in passive design, factors such as material used for seals and installed U-values are coming under greater scrutiny,” said Fakro sales director Andrew Prosser. “The tendency often is to consider types of window as broadly generic, but recent developments have improved the thermal efficiency of some products, leaving others behind. As a consequence, the U-value of, for example, centre pivot roof windows with an outwardly similar glazing unit can vary by 30-40%.”

For two passive house standard design studios at Arts University Bournemouth, which won an LABC (south west) award for building excellence, 24 Fakro FTP L5 and FNP L5 non-vented roof windows were specified by the designers, Frias Robles Associates. Arts University vice chairman Stuart Bartholomew said: “We hope the project will encourage other universities to adopt the passive house standard.”

The new Fakro units feature flexible thermoplastic elastomer (TPE) seals which retain their elasticity and dimensional stability. Fakro said that tests have demonstrated there is virtually no air leakage through a quadruple seal Fakro system.

Andrew Prosser added: “The increasing complexity of roof window design has drawn attention to timber quality and source, method of construction and the ability to adapt designs to meet specific performance requirements. With the roof and windows in traditional buildings each accounting for 25-30% of a building’s heat loss, the value of mitigating solar gain, thermal loss and air leakage through use of efficient roof windows can’t therefore be overstated.”

(above & right) Fakro’s quadruple-glazed FTT U8 window features thermoplastic elastomer seals to reduce air leakage

## Isocell launches products, technical literature & website

Airtightness products manufacturer Isocell have updated their website and technical documents to make both easier to navigate and read. "A lot of work and effort has gone into the design details of our new technical documents and website to offer clients and readers an easier and more informative read, in order to help them identify the benefits and uses of our range of products in an easy manner,” said Isocell’s Stuart Prause.

“We hope that this will facilitate home-owners, builders, architects and specifiers alike in choosing and specifying the most suitable products from our range. We are of course always at hand to offer advice and support if and when needed.” Prause said that the new designs will help Isocell to continue growing its customer base in both Ireland and the UK.

Isocell has also announced that due to “overwhelming demand” from its customer base, the company is now offering its Airstop Flex adhesive tape with split backs. “Our 75mm split back product is ideal for corner junctions or between membranes and walls, and can be plastered in with ease. This product is highly successful."

Prause said thirty kilometres of Isocell 75mm Airstop Flex airtight adhesive tape was recently used for sealing the new students’ residence at the University of Hertfordshire.

"In addition to this we have introduced our new Flex Fee 60mm wide window and corner tape," he said. "This uses the same high performance adhesive as the Flex range, and offers the ideal technical attributes for around window details, while at the same time offering a cost-effective solution, and a quick and easy installation as it can be plastered in.

“The Airstop Flex product is one of the best tapes on the market, not only in its ability to seal and its longevity, but in its range of applications," he said, adding that it can be used without primer on clean dust-free blockwork or concrete, timber, OSB, plywood and for sealing membranes inside and out. "It is also easier to handle and use then other products on the market. This is not just our opinion, but this is also the feedback our customers are giving us,” said Prause.

(left) The Isocell Airstop Flex adhesive tape range is available in thicknesses from 50 to 150mm

# Building? Upgrading?

## Passive House Plus is here to help!

Are you designing, building or pricing a sustainable building? Whether it's an energy upgrade of a small house, or you're looking to achieve high green standards with a new home, office or factory, Passive House Plus can help.

Fill in your details below, or online at www.passivehouseplus.co.uk & your enquiry will be sent to the Passive House Plus advertisers that provide the products or services you need. If you fill out your postal address we'll even send you the next issue of Passive House Plus free of charge!

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**name:** ______

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**Site location (please list county):** ______

**Project type (tick box)**

New home ☐ Home renovation/upgrade/extension ☐ New commercial/public building ☐ Upgrade/extension to a commercial/public building ☐

Other (please state): ______

**Floor area (approx. $ft^2$ or $m^2$):** ______

**Budget (approximate):** ______

**Stage (tick box)**

Initial appraisal ☐ Pre planning ☐ Planning approved ☐ Pre tender ☐ Commencement notice ☐

**Project imperatives (tick box)**

Certified passive ☐ Near passive/low energy ☐ Indoor air quality ☐ Low running costs ☐ Low environmental impact ☐

Other (please state): ______

**Estimated start date (please state):** ______

**Just tick the products/ services you would like more information on:**

- Airtightness & draught-proofing products ☐
- Architects ☐
- Building contractors ☐
- Central vacuum systems ☐
- Cladding & renders ☐
- Demand-controlled ventilation ☐
- Dry screed boards ☐
- Energy consultants ☐
- External insulation ☐
- Healthy building materials ☐
- Heat pumps ☐
- Heat recovery ventilation ☐
- Insulated concrete formwork ☐
- Insulation ☐
- Low energy lighting ☐
- Natural wood finishes ☐
- Passive house & low energy build systems ☐
- Passive house consultants & designers ☐
- Passive house training courses ☐
- Solar photovoltaic ☐
- Solar thermal ☐
- Steel frame build systems ☐
- Structural insulated panels ☐
- Thermal building blocks ☐
- Thermal breaks ☐
- Timber frame ☐
- Underfloor heating ☐
- VOC-free paints ☐
- Windows, doors & roof lights ☐
- Wood fuel / biomass stoves & boilers ☐

I would like my project to be considered for feature in Passive House Plus (tick box) ☐

# How to save money when building a low energy house

*Designing and building a passive or very low energy house requires exacting attention to detail and careful choice of building components, which can scare off potential enthusiasts who might be afraid of costs spiralling out of control. But quantity surveyor **Michael McCarthy** says that with forward planning, you can keep tight control of costs and deliver low energy buildings on a very tight budget.*

Photo: Dermot Sullivan

Increasing awareness of comfort levels, sustainability and design quality has resulted in passive house becoming a premium building standard that more and more people are aspiring to. The build costs for meeting the passive standard can vary enormously however. There are many factors that can affect build cost. These include:

- Floor to wall ratios; or the efficiency of the plan shape.
- The fabric components; including ratio of glass to walls, type of external walls, roof and foundations.
- Mechanical and electrical scope; the type of plant installed and the scope of electrics
- Ground conditions; impacting on the type of foundations, reduced level or imported fill, water and waste disposal.

> "With the passive house standard, because of the level of detail and the bespoke solution for each site, indicative costs per square foot cannot be relied upon."

No two buildings are the same. There are individual characteristics with each building and site that affect the standard metric of cost per square foot. With the passive house standard, because of the level of detail and the bespoke solution for each site, indicative costs per square foot cannot be relied upon. In order to be aware of — and in control of — costs, it is very important from the earliest possible stage to plan building costs methodically and in detail. The earlier this is done in the design process, the easier it is to take control of the project budget. This will ideally occur at pre-planning stage. That way, any design alterations can be incorporated without losing time to the process of changing planning permission and re-applying.

There are times when a client's aspirations to the passive house standard and their budgets don't match. In this instance, through the cost planning process, the most cost-effective elements of low energy design can be retained to meet that budget.

One such case has been a project I worked on from early in the design process. The client approached me and wanted a very low energy building for a very low budget. It was a huge challenge and involved very detailed cost planning of the options to meet the client's requirements. Other client requirements included underfloor heating, heat recovery ventilation and a good level of airtightness. We were also able to source a "shop soiled" heat pump for less than the price of a brand new unit.

This was The Barn House, which has steel framing with stick-built timber frame infill. The walls feature both cellulose and PIR insulation and have a U-value of 0.16, while airtightness is 2.4 $m^3/m^2/hr$. It received planning permission on the site of an existing agricultural barn. The plan was to replace the existing barn with a domestic house of the same proportions.

The full range of cost planning, tendering and project management services delivered an A3 Building Energy Rating for €70 per square foot including finishes, fittings, landscaping and VAT. This was exceptional value for money and would be very difficult to repeat. However, with detailed cost planning and commercial management from the outset, it is possible to get very good value for money.

Cost planning is just one part of the commercial management provided by a quantity surveyor. Once the magic budget figure has been reached, the process of tendering can begin. The detailed cost plan is then taken and developed into a bill of quantities (BOQ) for the purpose of tendering. The BOQ provides contractors with a level basis on which to price a tender and for the client's team to assess returned tenders.

The cost plan and BOQ processes help to tease out specifications for a client and their design team. This helps to reduce the occurrence of variations during the build. Variations are unforeseen extras such as ground conditions or remediation of existing structures in a renovation project. They can also be client requests for extras or alterations that were not originally included in the design or specification.

There are inevitably circumstances where variations occur. Should this be the case, there is a detailed schedule of competitive rates derived from the tendering process.

A pricing schedule or BOQ is prepared according to a set of measurement rules (there are separate rules for the UK and Ireland, prepared by the RICS and SCSI respectively). These are industry standard rules by which to procure building works. They are understandable by everyone involved in a project and improve transparency, accountability and communication between all parties.

The cost management process can also help to reduce an architect's risk and workload. If a project is tendered without being costed and that project comes back over budget, there can be a significant amount of time wasted by re-drafting and re-pricing a design. If there is no quantity surveyor involved, often an architect may enter negotiations with the lowest tender to reduce the price of a project. Here the advantage of a competitive tender can be lost as the competitive tension of a tender situation no longer exists.

Should a project be costed before tender, adjustments can be made to the design to ensure it is within budget before tendering begins. This will save the architect time and resources and will ultimately save the client time and money as well.

*Michael McCarthy is a chartered quantity surveyor with MMC in Cork, & specialises in energy efficient building projects*

# MIND THE GAP

## - The solution to air leakage

The Problem - In many constructions, about half of all heat loss is due to air leakage through the building. Given that approximately half of all energy used in the UK is from buildings, it is easy to see that air leakage, or draughts, account for a considerable amount of energy - and therefore cost.

As thermal insulation requirements have increased over the last few years, the proportion of energy lost through air leakage has become more evident. The ever-increasing thermal insulation required will however be rendered largely ineffective unless the airtightness of the structure itself is addressed. Tests indicate that air leakage can reduce the effectiveness of thermal insulation by up to 70%; therefore if energy efficiency is to be improved within buildings,

this is the most critical area to focus on.

In addition to improved insulation, energy efficient heating systems will also be ineffective if warm air can escape the building and cold air can seep in. This is reflected in the fact that total space heating costs in an airtight building may be as much as 40% less than in a leaky one.

Another issue associated with a leaky building is that warm and often moist air can escape to colder parts of the outer construction where it can cool and condense, leading to a build-up of moisture. This in turn can lead to:-

- Decay of organic materials such as timber frames.
- Saturation of insulating materials, thus reducing their insulative effect (further increasing heat loss).
- Corrosion of metal components.
- Frost damage where moisture has accumulated on the cold side of the insulation.

Air leakage through cracks, holes or gaps causes a significant reduction in the thermal performance and efficiency of a structure. However this can be remedied by careful design and good quality construction practice.

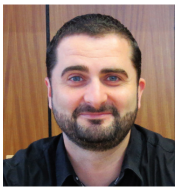
The Solution - Wraptite-SA and Wraptite Tape are effective methods of stopping unwanted air leakage. Wraptite-SA is a self-adhering air barrier membrane which consists of a triple layer polypropylene micro-porous film laminate with a proprietary moisture vapour-permeable adhesive, plus a silicon-coated PET release liner. It can be used in full wall applications, on pitched roofs (under metal, tile, slate, wood shingles and clay tile) and for window flashings or other details.

Wraptite-SA combines the best properties of a vapour-permeable membrane and air tightness in one innovative, affordable self-adhering product. It fully bonds (no primer or mechanical attachments required) to almost any substrate for air tightness and ease of installation, negating the requirement for sealants or tapes.

Penetrations in sheet material such as pipes, ducts and electrical work also need to be sealed to stop air leakage from a structure. Wraptite Tape has all the benefits of Wraptite-SA, but with the convenience of a tape. Air-tight Wraptite Tape is tear resistant and offers high vapour permeability for internal and external applications. It is also suitable for permanent air-tight sealing of membrane overlaps. Detailing is quick and easy, providing an effective, convenient solution to what can be an expensive problem.

Wraptite: All-in-One - Wraptite products do not require a primer and can be installed in temperatures as low as 0°C.Its wide service temperature range means it can be easily installed in all climates. It is very easy to install, with a tough facer laminate that resists rips, punctures and tears. Wraptite is fully bonded, hence fasteners are not required at installation; this prevents lateral air movement, further enhancing the building's thermal performance. Being highly water vapour permeable, Wraptite thereby reduces potential for trapped interior moisture and condensation. Wraptite is resistant for up to six weeks of UV and climate exposure.

Wraptite-SA and Wraptite Tape are unsurpassed in performance. Both offering an SD rating of 0.039, Wraptite-SA and Wraptite tape provide a highly vapour-permeable, yet air-tight performance for a wide variety of applications and conditions. They allow damp sheathing to dry quickly and moisture vapour to escape, ensuring good indoor air quality while reducing incidence of mould, mildew, condensation, timber distortion and metal corrosion. The unique characteristics of Wraptite allow the moisture vapour to escape the structure easily, while fully maintaining the integrity of the air-tight building envelope.



# We must insist on hyper local climate data for passive houses — & all buildings

*The design of buildings must be based on accurate local climate data or we risk exacerbating the performance gap, says architectural technologist **Evan Finegan**, who is leading new research to demonstrate the big difference in heating demand just a few hundred miles can make.*

Research currently in progress at Cork Institute of Technology aims to define the characteristics of an 'optimum energy' dwelling, in an Irish context. The goal is to design a dwelling which applies the inherent qualities of a passive house, while considering the conditions in which this dwelling is constructed and operates. One of these conditions is the local climate, which varies across Ireland.

The dwelling design is developed using a symbiotic design approach, whereby the impact of a design decision at scheme design stage is assessed using the Passive House Planning Package (PHPP). The impact of this decision then informs the design process. Once the dwelling's energy balance is optimised using a static Dublin data set, the dwelling performance is tested in 14 locations throughout Ireland.

"Without such accuracy in data we run the risk of promoting a poor image for low energy buildings, where predictions and performance figures are a bridge apart."

The result of such a study should highlight the potential variations due to climate. As this is a comparative study, the 14 locations are identified by Met Éireann synoptic data station locations, which record 30 year averages. Data sets are then generated for these locations using Meteonorm software, while using an approved PHPP data output.

By comparing the performance in all 14 locations, and examining the best and worst case scenario, it can be seen that the dwelling performs best in Valentia, Co. Kerry on the south west coast, with an annual space heat demand of 5.8kWh/m$^2$/yr. The worst test performance is in Clones, Co. Monaghan, where the test dwelling performs at 12.2kWh/m$^2$/yr. This effectively means that one would expect to use 210% of the energy to heat the test dwelling if built in Clones, to that of the test dwelling constructed to the exact same standard in Valentia. The average annual space heat demand for all 14 locations is 8.33kWh/m$^2$/yr (from here on referred to as the baseline average).

The Valentia test dwelling has a space heat demand 33.8% below the baseline average; while in Clones the space heat demand is 39.2% above the baseline average. It is worth noting that as the test locations are based on synoptic stations, which are ideally located to detect optimum weather conditions in a very localised area, the result derived from each data set would be of the conservative nature, particularly when considering solar gain. A site which is located in a valley, or indeed with a mountain to its southern elevation, would perform substantially worse due to a reduction in solar gain.

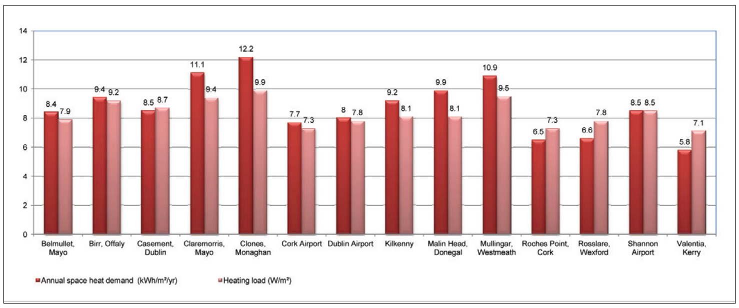
By further examining the data it is evident that Clones does not have the lowest average winter time temperature, yet the test dwelling has the greatest recorded heat losses here at 50.4 kWh/m$^2$/yr. Clearly this inland location is impacted upon by greater peaks and troughs in temperature. When the solar gains and internal gains are offset against heat losses, the dwelling performs at its worst in this location. The solar gains however are not recorded at their worst in Clones, where they contribute a total of 27.16kWh/m$^2$/yr. Perhaps surprisingly, although heat losses are lower in Valentia at 41.73 kWh/m$^2$/yr, the 'advantageous' solar gains are lower than Clones at 24.47 kWh/m$^2$/yr. The solar gains in PHPP only consider advantageous solar gains. Valentia may have more actual solar radiation across the 12 months of a year, but the balance may provide for a lower contribution overall. This may be attributed to higher gains in the summer, whereas Clones may have higher winter gains due to clearer winter skies. Given that our prevailing winds are south westerly, it stands to reason that cloud cover should be lower in Monaghan as it's so far from the Atlantic coast. This may have more of an impact in locations like Valentia, although temperatures may be higher which provides for a lower heat loss and heat demand. My PhD will provide a more detailed breakdown in this regard.

It is evident that there is a very fine balancing act at play here. Solar gain and heat losses must be considered in tandem, and not as independent entities. Clearly the dwelling should be designed and the performance simulated for a specific location, to ensure that the building will perform in accordance with the simulated data.

This raises the question: where a dwelling is not constructed to passive house standards, how then can we determine the energy performance using a generic climate data set for all of Ireland? The simple answer is that we cannot. Why then do building energy ratings (BERs) rely on a single data set? The fact is, the Deap software, used to generate a BER rating, is not a design tool. The use of a purpose built design tool, with local climate data may be more insightful, while leaving the Deap software to analyse such legislative requirements as Part L compliance and BER ratings.

In terms of designing a building to achieve an optimum energy balance, it is strongly advisable that the local climate is considered, and that the assessment tool used to predict the energy performance at design stage accounts for local climate conditions. Without such accuracy in data we run the risk of promoting a poor image for low energy buildings, where predictions and performance figures are a bridge apart. With the given exception of unpredictable user patterns, we must ensure that a building is designed to accommodate fixed, known, and available parameters, in order to accurately represent and actively promote a reduction in energy use to the general public.

*Evan Finegan is a researcher at Cork Institute of Technology and Director at Hiras Finegan Architecture*



# INTERNATIONAL SELECTION

Photos: Achim Große

This year's international Passive House Awards featured 21 projects — out of about 100 entries — across six different categories, with shortlisted projects coming from across Europe plus New Zealand, South Korea, and the United States. In this issue's international section, we pick four buildings from an exceptional selection.

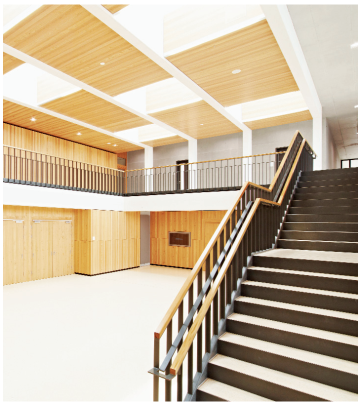
## Riedberg school, youth centre & gym

**Shortlisted: Educational Buildings**

This certified passive house development comprises a grammar school, youth centre and three-court gymnasium in the new district of Frankfurt-Riedberg, where an urban quarter is being built for 15,000 residents. It emerged from a competition that asked architects to design a pioneering school complex that would serve not just students but local residents too. The educational spaces were opened-up to encourage interaction and the exchange of ideas rather than confining teachers and students to separate classrooms. In the centre of each schoolhouse is an open atrium that serves as a common area with seating spaces for group learning.

Designed by Ackermann and Raff Architects, the complex was completed last year. It features several different buildings, and has its own internal roads, courtyards and outdoors spaces — all designed to interweave carefully with the surrounding neighbourhood.

The buildings were constructed from prefabricated concrete elements. With so many students to occupy them, cooling was one of the biggest challenges for the design team. The assembly hall and canteen, which have a particularly high thermal load, feature an adiabatic cooling system: the temperature of extracted air is cooled by spraying it with atomised rainwater, and the HRV system then recycles this cooler temperature into incoming fresh air. Meanwhile controlled air circulation cools the schoolhouses at night: motorised vents in the facade and roof open up, creating a chimney effect in the high atria which draws warm air out. ▶

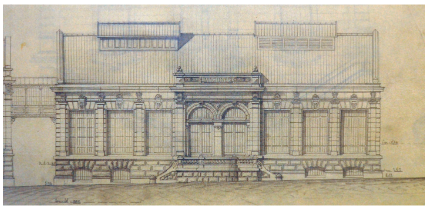


## Atelier Rivat, Saint Etienne

**Shortlisted: Retrofits**

This remarkable retrofit turned a historic monument, built in 1902, into a certified passive office for its own architects. Externally insulating the facade was out of the question, so the architects Atelier d'Architecture Rivat went for a box-within-box approach to insulating the structure, creating a new thermal envelope inside the old walls, with a ventilated cavity in between. The new internal fabric is of timber frame with mineral wool insulation, and the building is now heated by a ground source heat pump drawing from 100 metre deep boreholes.

A Zehnder heat recovery system ventilates the building, while rainwater is captured to provide water for the toilets and sprinklers. The building's heating demand is 12 kWh/m$^2$/yr, heat load is 16 W/m$^2$, and its airtightness is 0.54 air changes per hour — all pretty exceptional results for a building that's more than 100 years old. Meanwhile wall, floor and roof U-values are 0.15, 0.16 and 0.12 respectively. Occupied since November 2013, the architects say that the building's consumption of energy for heating has been almost exactly as it was modelled in the passive house software PHPP. ►



Photos: Atelier d'Architecture Rivat/David Philippon

## Artist's Studio, Long Island

**Shortlisted: Office and Special Use Buildings**

This simple 100 square meter painting studio is located on a bluff overlooking Long Island Sound. The goal of architects Ryall Porter Sheridan was to create a super low energy artist's studio with net-zero energy use.

The thick timber frame walls are packed with blown cellulose insulation. To visually deal with the bulky walls, thin aluminium extensions transition to deeply recessed triple-glazed, operable Pazen casement windows.

Salvaged wood cladding from demolished New York City buildings forms a rainscreen for the building, while a small air-to-air heat pump supplies heating and cooling.

The building has an annual energy usage of 2200kWh, but this is offset by its solar photovoltaic panels, which produce more than twice this amount.

The studio interior is illuminated by north-facing clerestory windows, which satisfies the artist's requirement for a light-filled space without the glare of south-facing glass. Two-thirds of the building's heating load is supplied passively with a south-facing wall of light-capillary panels, laminated onto a masonry wall that stores and radiates heat inside. The wall, floor and roof U-values are all between 0.10 and 0.12, while the heating demand of this certified passive house is 14kW/m²/yr. ▶

Photos: Ty Cole

Photos: Sea Pietschmann/ Deimel Ölschlager Architekten

## Boyenstrasse zero-emission apartment block, Berlin

**Winner: Apartment Buildings**

Finished in May 2013, this seven-storey apartment block in Berlin is designed to produce more energy than it consumes, boasting solar photovoltaics plus its own gas-fired combined heat and power plant. The building was constructed from a masonry core with timber facade panels that are insulated with cellulose.

Developed as a co-operative by the apartment owners, the certified passive building places big emphasis on community spaces, like the shared roof terrace, garden and common room. Designed by Deimel Ölschlager Architekten, it was built to adapt to the future needs of its inhabitants: for example, the large family apartments at the centre of the complex can be easily split into two small units in future.

Each unit is heated by heat recovery ventilation plus a single towel radiator, while incoming air is routed underground to preheat it in winter and cool it in summer. The complex also boasts greywater recycling and a green roof. Timber-shades on the south-facing balconies help to control the amount of daylight entering the 21 units. The U-values for all the opaque facade elements are below 0.11 or less, while heating demand is just 8 kWh/m$^2$/yr, and airtightness is a super-tight 0.27 ACH.

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# BUILDING A BETTER PASSIVE SCHOOL

The team behind a series of passive house schools in Wolverhampton have used the lessons learned from in-depth monitoring of the first two buildings to make the third even better — and cheaper to build.

**Words: Kate de Selincourt**

Architectural photos: Dennis Gilbert/View & Tom Mason

Wilkinson School is the third passive house school built for Wolverhampton City Council by the same collaboration of architect, contractor, timber frame company (for two of the three), passive house consultants, and M&E consultants.

In 2011, the team completed their first two passive schools for Wolverhampton, Oak Meadow and Bushbury, even though they were restricted to a standard school budget. Feedback from the teaching staff at these schools has been good. The head teacher at Oak Meadow, for example, reported that staff felt children were "more alert and attentive ... due to the amount of daylight and fresh air."

After the previous Wilkinson School building was destroyed by a catastrophic arson attack, the head, who had been impressed with the quality of the buildings at Bushbury and Oak Meadow, told Wolverhampton City Council she wanted the same for her students.

By this time the standard budget had been cut by 10%. But the same team was able to work together again, and could take advantage of what had been learned to date to deliver this latest school more quickly and efficiently – and at a lower capital cost. The one concession made by Wolverhampton was that, as energy use and emissions would be so low anyway, there was no need for the on-site renewables usually required by the council.

Wilkinson, like Oak Meadow and Bushbury before it, is a two-storey school: this makes passive house easier and cheaper to achieve (two-storeys are not unusual in larger primary schools, and leave the school more outdoors space).

As with their previous school designs, Architype incorporated some of the specialist teaching areas such as IT and cookery into the circulation space, enabling them to create the wide, daylit double-height 'streets' which contribute to the spacious feel inside.

Wilkinson uses the same basic construction method too: an externally insulated timber frame, set on a slab with insulation beneath, and has a similar approach to building services, with gas boilers and radiators providing the heating.

However, careful analysis of the performance of the first two schools enabled the team to identify some expensive features that were not really necessary, and the construction team (timber framers Cygnum and Thomas Vale Construction) was able to refine its approach to accommodate the needs of a passive house build more smoothly. This all contributed to a simpler and cheaper process.

**Glazing design**
The classic passive house tends to have large areas of south facing glazing, and Bushbury and Oak Meadow were no exception. Experience with these two builds enabled a more tailored glazing design for Wilkinson that saved money, and quite possibly improved comfort and performance too.

Typically in a passive building, internal heat gains provide about a third of the total heating. As schools are densely occupied compared to houses, body heat is a major contributor to internal gains.

However, the assumptions underlying school ▶

occupancy in the Passive House Planning Package (PHPP) relate more closely to German schools than British ones. Looking at a sample of schools, Nick Grant of Elemental Solutions calculated that British schoolchildren are squeezed into approximately half the space available to their German counterparts – so contribute twice as much body heat per square metre of classroom.

Compared to the PHPP "standard" school, this translates to a very handy additional 5-6 $kWh/m^2/yr$ of useful heat across the heating season – and a less welcome extra burden of unwanted gains when it's warm.

Elemental Solutions realised they could reduce the amount of solar gain from south glazing without endangering the heat demand ceiling of $15kWh/m^2/yr$, because these additional gains would make up the difference. Reducing the amount of south glazing would in turn reduce unwanted gains in warm weather – and save money. It could even improve daylighting, as tall windows need deep (wide) shades – which in turn reduce sky view, and therefore daylight.

"The school is so well-insulated that the boiler is no longer 'mission critical' — the school can stay open even if it breaks down"

The snag of course is that such a building would show up as needing over $15kWh/m^2/yr$ of added heat in PHPP, because of the software's lower heat gain assumptions. However, Elemental Solutions wrote to the Passive House Institute explaining the case, who agreed they could use a more realistic figure based on UK school occupancy levels.

Thus, one of the main differences between the glazing at Wilkinson School and its predecessors is that the classroom windows here generally stop at around desk height, rather than dropping to the floor. This is simpler, cheaper – and gives more useful space.

Even with reduced areas of south-facing glazing, any building is at risk of overheating in hot weather without good purge ventilation. While MVHR running on summer bypass can remove quite a bit of heat, wide-open windows can do more, and the strategy in all Architype's passive buildings is to provide generous natural ventilation for this.

Nevertheless, some of the south-facing classrooms in the team's first two passive schools became a bit warm – at 25C it was nothing drastic, but staff found it uncomfortable. As well as the floor-to-ceiling glazing, there were also some difficulties getting the windows to open.

Some low-level windows were so large they had to be mechanically operated, and the opening had to be restricted to avoid any possibility of fingers becoming trapped. Meanwhile the high-level ventilation in the curtain walling did not perform perfectly either. Curtain walls, although they look lovely, present some practical problems. "This was a big lesson we learned as architects," says architect Lee Fordham of Architype.

The openings were also very close to the ceiling, restricting airflow. And the lack of frames in the curtain walling caused problems with the actuator siting, leading to cables getting caught in the windows.

With Wilkinson, these lessons were learned. The building has windows built conventionally into the walls: quicker to install, easier to make airtight – and a lot cheaper. "The way we have framed the windows looks very nice, we are very pleased with the elevations," Lee Fordham says.

A similar change was made to the daylighting for the spacious double-height circulation spaces. Instead of continuous "curtain roof" glazing, Wilkinson has simple skylights, as Alan Clarke of Elemental Solutions explains. "Upwards-facing glazing lets in most sun when the sun is highest, but solar gains are least welcome. So now we have individual skylights just sized for daylight. There is less overheating, a big cost saving, and no leaks."

After the experience with the first two schools, says Lee Fordham, "we realised that the occupants were better at controlling their comfort than the BMS was. BMS is not always in tune with user needs; it can also be distracting when it keeps opening and closing the same window, making a buzzing noise each time." At Wilkinson the smaller, lighter, low-level windows are all manually operated.

Instead of relying on the BMS to control purge

(clockwise from above) The foundation sits on 250mm of high density Jablite Jabfloor rigid EPS insulation consisting of two staggered layers; the airtight layer consists of Smartply OSB3 with careful taping at junctions and between panels; wrapped glulam ends visible through structural zone; a windtightness detail; a site inspection by passive house consultant Nick Grant; Service penetrations in the timber frame waiting for ductwork.

ventilation, Wilkinson has secure night vents. These are inward-opening casements that can be opened to 90 degrees and fixed back out of the way, for the full benefit of the cool air. Many are at low level so can be manually operated.

**Heating and hot water**

With heat loads as small as they are in passive buildings, Elemental Solutions are inclined to offer simple advice. Running costs and emissions will be low whatever the heat source, so it makes sense to go for a system that is familiar, reliable, and inexpensive – hence the use of simple gas boilers and radiators, with local control via thermostatic valves, for all three of the schools.

The team took advantage of the BMS monitoring information from the first two schools to refine their design decisions at Wilkinson. The systems specified for the earlier schools – two boilers, and two large radiators per classroom – were much larger than needed. At Wilkinson the heating system supplies one modest radiator per room, saving money and freeing up wall space.

Not only are the radiators smaller and fewer. Unusually for a school, there is only one boiler. Alan Clarke explains: “The school is so well-insulated that the boiler is no longer ‘mission critical’ — the school can stay open even if it breaks down. Other schools not only have to have much larger boilers, they need multiple boilers in case one fails.”

Monitoring at Bushbury and Oak Meadow also enabled a simpler hot water design. There, the majority of the heat used by the hot water system turned out to be disappearing as circulation losses. At Wilkinson it was decided to use a dispersed system instead, with small electric heaters supplying just four or five rooms apiece, via small bore pipework, to minimise losses.

**Ventilation**

For background ventilation, because the number of people in the building is so predictable, it was not necessary to cater for all eventualities.

Thus rather than the standard approach of providing air changes to each room to match the maximum number of occupants it might contain (ie, basing supply on floor area), it was possible to subdivide the building into fewer zones, and supply air in at one end, cascade it through, and extract at the other, as the same number of occupants will always be somewhere in the cascade. This greatly reduces the amount of ductwork required, compared with supplying and extracting from each room separately.

For the school hall, occupancy varies widely (from no-one to the whole school community), so here a $CO_2$ sensor is used. When the hall is in use, air is brought in through the wall from the internal 'street'. When everyone is in the hall, the air arriving into the 'street' from the classrooms is fresh, because the classrooms are empty – thus there is no need for a separate supply from the main unit.

Initially the plan was to ventilate the schools naturally (ie by window-opening) in summer, with no MVHR. However, as Lee Fordham explains, although you can turn the heating off in summer with no problem, people need to be told to switch to natural ventilation when the MVHR shuts off.

In practice, continuing to run the ventilation but on summer bypass is simpler: good ventilation is assured, and occupants can still use natural ventilation for additional comfort, which they don’t need telling to do. “This is worth the little bit of extra energy used,” Lee Fordham believes.

Monitoring and occupant feedback on electricity use at the first two schools proved invaluable too. Here the lighting had supposedly been controlled by BMS, but in practice this left lights on when they weren’t needed, with no way to turn them off. For Wilkinson, lighting controls were mostly ditched, along with the expense.

**Easier construction**

The construction system for all three schools has been developed by Architype and their construction colleagues. It wraps a continuous ‘duvet’ layer of insulation around the outside of the frame and under the floor.

As Lee Fordham explains: “To create a continuous layer of insulation the solid concrete floor floats over 250mm EPS. The load is spread evenly through the EPS, rather on the same principle as snowshoes, so this causes no structural problem.

“By contrast you can’t get the same continuity with external insulation if you have a suspended floor, as you have to insulate above the floor structure.”

Although Oak Meadow and Bushbury schools had freestanding glulam structures entirely inside the thermal envelope, with the reduced budget at Wilkinson School this would have cost too much, as Mark Smith of Cygnum explains. Instead, there is a load-bearing stud wall in the first (inner) 140mm of the 340mm insulated space. The outer 200mm is created ▶

by Larsen trusses, and the full thickness is insulated with blown cellulose insulation. On-site assembly means less timber needs to be used in the outer section, minimising thermal bridging in the all-important 'duvet' layer.

Inside, the team has built on the experience of maintaining airtightness in the first two schools and the continuous OSB airtight layer is prioritised, ensuring it has as few joints as possible.

Previously, internal floors and load-bearing internal walls were notched into the frame, as part of the strategy to ensure the building does not collapse if one part is damaged. However, this means the airtight layer had to lap around the outside edges of the floor and walls, introducing three extra corners, meaning a lot of joints and a lot of tape. As Mark Smith explains: "We now use a different structural strategy to deal with disproportionate collapse, and keep the airtightness layer as a flat plane."

Cygnum has embraced this approach, and now supplies drawings with all the airtight lines carefully marked in. Mark Smith says: "Some coloured lines on a boring section really make a difference. It makes it much easier for everyone to understand how the building works."

The experience of the previous builds using the same system has enabled the team to come up with other apparently small refinements that nonetheless make life a lot easier on site.

For example, contractor Thomas Vale has perfected the way it tapes the windows – eliminating hundreds of pin-sized potential holes; and the way the walls are now prepared to receive the roof makes subsequent taping of the air barrier between them much more straightforward.

**How is the school working?**
The formal monitoring and soft landings process at Wilkinson School is due to begin in September 2014, so the feedback is only informal as yet. Monitoring that has taken place suggests that temperatures are stable. More importantly, the occupants are comfortable. According to head Tina Gibbon: "The school feels very airy, and it's very quiet. It's warm in winter, but it also performed very effectively in the recent hot weather."

Building, then studying, a series of passive schools has enabled a lot of streamlining, and seems to offer the much-hoped-for reductions in the passive house cost premium. Critical to these savings, however, was the close teamwork and full buy-in from all parties. "It would have been impossible without the continuity of the main firms involved," Lee Fordham believes.

Everyone gained from putting aside "the way we've always done it" and responding to the specific requirements of passive house. But just as valuable, everyone – and the budget too – gained from identifying and omitting the expensive and complex features that passive house manages perfectly well without.

**SELECTED PROJECT DETAILS**
**Client:** Wolverhampton City Council
**Architects:** Architype
**Project manager:** Carillion
**Principal contractor:** Thomas Vale Construction
**Timber frame:** Cygnum
**Passive house consultants:** Elemental Solutions & Alan Clarke
**Mechanical & electrical engineers:** E3
**Structural engineers:** Price and Myers
**Landscape architects:** Coe Design
**Airtightness products:** Pro Clima/Siga
**Cellulose insulation contractor:** PYC Insulation
**Windows/doors/curtain walls:** Raico & Gutmann, via Pacegrade Joinery
**Rooflights:** DVS Ltd
**Roof joists:** Steico
**Building boards:** Fermacell
**OSB:** Smartply
**Sheathing boards:** SIG Insulation
**Cladding:** H&H Alloys
**Ceilings:** Troldekt
**Quantity surveyor:** Smith Thomas Consult (since acquired by Ward Williams Associates)
**MVHR:** Swegon
**Condensing boiler:** Remeha

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## PROJECT OVERVIEW:

**Building type:** two-storey school, 2610 sqm gross internal floor area, timber frame with Corten steel and Wienerburger Corium brick façade.

**Location:** Bilston, Wolverhampton, United Kingdom

**Completion date:** February 2014

**Budget:** £5.05m (construction cost)

**Passive house certification:** pending

**Space heating demand (PHPP):** 11kWh/m²/yr

**Heat load (PHPP):** 9 W/m²

**Primary energy demand (PHPP):** 111kWh/m²/yr

**Airtightness (at 50 Pascals):** 0.34ach

**Energy performance certificate (EPC):** A25

**Ground floor:** various floor finishes on 300mm power floated concrete slab, on low permeability gas membrane, on 250mm high density (Jablite Jabfloor) rigid EPS insulation consisting of two staggered layers. U-value: 0.064

**Walls:** 12.5mm Fermacell boards internally, followed outside by 38mm service zone, 18mm OSB-3 taped at joints (airtightness line), Cygnum timber frame consisting of: 140mm structural zone with cellulose insulation (Warmcel 500), 200mm insulation zone with fully-filled Warmcel 500, 15mm T&G Bitroc sheathing boards, butt joints taped (wind-tightness line, ventilation zone comprising timber battens (minimum 50mm), external cladding. U-value: 0.13

**Flat roof:** 12.5mm Fermacell boards internally, followed above by 18mm OSB 3 taped at joints (airtightness line), and Cygnum timber-frame consisting of: 250mm roof joists (TJI, Steico), 18mm OSB, 250mm insulation, Sarnafil single ply membrane. U-value: 0.1 W/m²K

**Pitched roof:** 12.5mm Fermacell boards internally, followed above by, 18mm OSB 3 taped at joints (airtightness line), and Cygnum timber frame consisting of: 350mm Roof joists (TJI, Steico) fully filled with Warmcel 500, 12mm timber vent, Pro Clima Solitex Plus membrane (wind-tightness line), 89mm ventilation zone, 18mm WBP plywood, Kalzip aluminium profile roofing with membrane. U-value: 0.1

**Windows:** Gutmann Mira Therm 08 triple-glazed aluminium-clad spruce windows, with argon filling and Swisspacer bar. Uf-value: 0.77; Ug-value: 0.54

**Curtain wall:** Raico Therm+ H-I triple-glazed aluminium clad timber frames, with argon filling and Swisspacer bar. Uf-value: 0.8; Ug-value: 0.54

**External doors:** Gutmann S80+ HW triple-glazed aluminium thermally broken and thermally insulated frames, with argon filling and Swisspacer bar. Uf-value: 1.8; Ug-value: 0.54

**Roof lights:** 3 x Lamilux CI System Glass Element FEenergysave skylights. Passive House Institute certified system with warm edge spacer bar, triple layered seal system & thermally broken frame. U-value: 0.84

**Heating system:** Remeha Quinta Pro QP90 (rated output 84kW) condensing natural gas fired boiler and radiators. Gross efficiency at 50C Flow, 30C Return is 104.1% (net 93.8%). Hot water is provided by a number of local electric water heaters to minimise distribution and storage heat losses. Microbore copper pipework is used for final pipework to keep hot water deadleg volumes to a minimum.

**Ventilation**
**Main school:** Swegon Gold 50 supply and extract air handling unit with rotary wheel heat exchanger. Heat recovery temperature efficiency 82%.
**Kitchen:** Swegon Gold 12 supply and extract air handling unit with run-around coil heat exchanger. Heat recovery temperature efficiency 57%.

**Green materials:** Fermacell boards, Warmcel cellulose insulation, Bitroc boards, Troldekt panels.

# Rural Durham home

## *mixes thoughtful design & passive aims*

Architectural technician Philip Newbold of New Bold Design describes how he overcome strict planning rules and a tight budget to build his sensitively designed, super low energy home in an area of outstanding natural beauty.

My wife Joy and I sold our leaky Victorian home in 2008 and started looking for a plot to build our own low-energy house. In 2011, shortly after I was made redundant from a senior associate's job with a leading architecture practice in the north east, we found a plot in Upper Weardale with what we thought was detailed planning consent. In fact it turned out the planning consent had expired in 2009. The seller had to re-apply, but we finally secured ownership of the plot in January 2012 for £70,000.

I had used some of my redundancy money to train as a passive house consultant and as we now had no significant income, we decided to use all the money we had to build a passive house, so that we would not have any major heating bills in future. We originally planned to build without a mortgage but in the end we needed £65,000 from the Ecology Building Society and £10,000 from the Bank of Mum and Dad just to make the house complete enough to live in. The total build cost so far is around £180,000.

The plot is 345 square metres and the village is in a conservation area on the river Wear. When we opened discussions with the plan-

ners on the 15 conditions, we found they were inflexible and not really interested in our aspirations to build a passive house. Thanks to draconian planning restrictions, out went any hope of being able to build a certified passive house. While I had hoped to build a more compact, cubic house, the planners insisted we conform to the Dales cottage vernacular of an L-shaped dwelling plus a lean-to extension.

Our new home is a two-storey detached house of 116 square metres (over two floors) with a non-habitable attic plant room and store. The ground floor comprises an open-plan dining hall and kitchen, lounge, WC, utility room and store. The first floor has a master bedroom, study bedroom, bathroom and WC, guest bedroom with en-suite shower and WC, and linen cupboard. The attic plant room and store houses the 250 litre hot water tank and the MVHR unit.

We started work in March 2012 and moved to a small, rented cottage next door to the plot.

the void was filled with 50mm PUR insulation board before a final lining of 12.5mm plasterboard and skim was added. In spite of incomplete stonework, no stove and no slates on the roof, we moved into the house in February 2013. We then installed a room-sealed wood-burning stove in the lounge with a back boiler that provides up to 8.5kW to hot water in the winter and also heats towel rails in the bathrooms and a heat-leak radiator in the linen cupboard.

We have no central heating system beyond the wood burning boiler stove and the house is maintained at a minimum of 20C. Solar thermal panels provide most of the hot water in the summer, topped up with the immersion heater, assisted by the output from our 1.5kW solar PV array.

We discovered that we could not get the feed in tariff for the solar PV until we had an energy performance certificate. But we could not get an EPC until we had a completion certificate from the building control officer. And we could

## The silent MVHR system recycles the heat generated inside the house while providing filtered, fresh air.

It didn't stop raining (or snowing) for about 10 months, and 2012 turned out to be the wettest summer for 100 years.

We cast the concrete floor slab over 450mm of EPS insulation in June. As the timber frame was erected, I inserted continuous Intello membrane with taped joints around the perimeter of the upper floors and roof in order to ensure good levels of airtightness. All the drain pipes and services penetrations through the floor slab and external walls were fitted with airtight grommets.

The planners had initially insisted on double-glazed, sliding sash windows, but I was able to persuade them to accept triple-glazed, mock-sash, tilt-and-turn casements with a U-value of 0.9. By September 2012 the roof structure was watertight, but just as the rain turned to snow, the windows and doors arrived from Lithuania, some weighing up to 70kg each. I applied special airtightness tapes internally and externally to all the frames before getting a local joiner to help install them. The same joiner helped me to line the internal face of the timber frame with Smartply 18mm OSB 3. We then primed and taped the OSB joints with Tescon tape using a heat-gun to dry the joints.

I also taped the joint between the OSB and the ground floor slab. When all the airtightness measures were complete, the blower door test gave a result of 0.59 air changes per hour. Using local stone, the stonemason managed to get the external stonework up to the ground floor window cills before the first serious snow arrived in November. As the coldest and longest winter for 50 years followed the wettest summer, progress on the stonework almost ground to a halt.

The internal OSB was lined with battens to create a 50mm services zone for pipes and wiring. After all the services had been installed,

not get the completion certificate until the stove flue, stonework, roof slates, electrics and rainwater goods were finished. This was finally achieved in October 2013, with the EPC giving the house an A rating.

As the house nears completion and we have occupied our new home for over a year, we are beginning to appreciate what all our hard work has achieved. We only need the stove burning on winter evenings and have no other fuel bills apart from electricity which is currently running at £35 a month, excluding the feed in tariff. The silent MVHR system recycles the heat generated inside the house while providing filtered, fresh air. There have been no overheating problems so far.

Despite costing around £250,000, the house is only worth £225,000 according to the Royal Institute of Chartered Surveyors, so building a one-off house like this in the UK is still too expensive. The clever components have to be imported and our workforce is just not good enough. The hybrid heating and hot water system is difficult to control and both solar systems have had technical failures.

But we have managed to self-build a Band A home to the cusp of passive house and have a warm, comfortable home in which to live and work without any significant heating bills. More importantly, we have proved that it is possible to build a real low-energy home in a conservation area, and an area of outstanding natural beauty (AONB), which fits in with the local architecture while addressing fuel poverty issues head-on. One day, all houses will have to be built like this.

Greendale Cottage was recently awarded the price for best individual new home at the 2014 Northern LABC Building Excellence Awards, and will go forward to November's national awards in London. ▶


# As the coldest & longest winter for 50 years followed the wettest summer, progress on the stonework almost ground to a halt.

**SELECTED PROJECT DETAILS**
**Design & project management:** New Bold Design
**Client:** Philip & Joy Newbold
**Timber frame:** Swift Timber Homes
**Windows & doors/MVHR:** Green Building Store
**Airtightness products:** Pro Clima
**Solar thermal:** Baxi
**Solar PV:** Panasonic
**Mechanical contractor:** Pure Energy Systems
**Airtightness tester:** Apex Acoustics
**Cellulose Insulation:** PYC Insulations
**PUR insulation:** Quinn-therm
**Floor insulation:** Springvale
**Basalt wall ties:** Ancon
**Stone cladding:** Dunhouse Quarry Co
**Wood burning stove:** Stoves Online
**Towel radiators:** Best Bathrooms
**Reclaimed roof slates:** Reclamation Supplies
**Finance:** Ecology Building Society

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(below right) the house is located in an area of outstanding natural beauty so there were strict planning restrictions to adhere to; (below left) triple-glazed mock sliding sash windows were installed to satisfy the planners without undermining thermal performance; (p37, from top) the timber frame being erected; Smartply OSB lines the internal face of the timber frame, with the joints sealed with Tescon airtightness tape; after all services had been installed, the void was filled with 50mm PUR insulation board; a continuous Intello membrane with taped joints around the perimeter of the roof ensures good levels of airtightness.

## PROJECT OVERVIEW:

**Building type:** detached 116 sqm three-bedroom, two-storey house with additional 48 sqm attic plant room and store.

**Location:** Ireshopeburn, County Durham

**Completion date:** June 2013

**Budget:** £250,000 (£70,000 for the site and £180,000 for construction)

**Passive house certification:** not certified

**Space heating demand (SAP)*:** 1014 kWh/year

**Water heating demand (SAP):** 2394 kWh/year

**Primary energy demand (SAP):** 16 kWh/m²/year

**Airtightness (at 50 Pascals):** 0.59 ACH

**Energy performance certificate (EPC):** A 97

**Thermal bridging:** Inner leaf of substructure walls in Durox Supabloc Aircrete blocks to minimise thermal bridging from the ground-bearing foundations into self-supporting concrete floor slab. Double-stud timber frame has a minimum number of small connecting strips of OSB between the inner and outer studs. Internal service zone battens are at right-angles to the frame studs to minimise thermal bridging. 150mm wide x 50mm thick PUR insulation around all openings between outer skin of stone and timber frame. All details are bespoke designs developed by New Bold Design in consultation with Swift Timber Homes.

**Ground floor:** 200mm thick self-supporting, reinforced concrete floor slab on 450mm Springvale EPS. Slab supported at the perimeter on 140mm inner leaf of Durox Supabloc aircrete blocks on reinforced concrete strip foundations. 200mm Springvale Platinum EPS insulation in a fully-filled cavity with Teplo-Tie basalt wall ties and outer leaf (to support stonework) of substructure perimeter walls in 100mm 7N solid concrete blocks. Radon barrier under insulation with lapped and taped joints. U-value: 0.08

**Walls:** 100mm thick, random, natural, local stone externally, followed inside by 50mm ventilated cavity, Tyvek membrane on 9mm OSB, 90mm outer studs, 50mm space, 140mm inner studs (studs at 600mm centres), 18mm Smartply OSB (airtightness layer) with joints sealed and taped with Tescon primer and tape. 280mm void filled after erection with Warmcel cellulose fibre insulation. Inner and outer studs connected top, centre and bottom on each storey with small 9mm OSB bridging pieces. 50mm internal service void for pipes & cables created using 50 x 38mm horizontal battens, filled with 50mm Quinn-therm PUR insulation between battens and finished inside with 12.5mm Gyproc Duplex plasterboard, skim coat and emulsion paint finish. U-value 0.12

**Roof:** Reclaimed natural grey slates externally on 50 x 25mm battens/counter battens, on Tyvek breathable roofing underlay, on 9mm OSB, on 300mm I-beams at 600mm centres, on 18mm Smartply OSB (airtightness layer) with joints sealed and taped with Tescon primer and tape. 300mm void filled after erection with Warmcel cellulose fibre insulation. 50mm internal service void for pipes & cables created using 50 x 38mm horizontal battens, filled with 50mm Quinn-therm PUR insulation between battens and finished with 12.5mm Duplex plasterboard inside, skim coat and emulsion paint finish. U-value 0.12

**Windows:** Green Building Store Ecocontract mock sliding sash, triple-glazed, factory-finished, timber windows and external doors. Large, mock-sash windows on the south elevation and small, casement windows on the north, east and west elevations. Windows U-value: 0.9, external doors: 1.1

**Heating system:** Woodfire F12 room-sealed, wood burning boiler stove in the lounge providing a maximum of 8.5kW to hot water and 1.5kW to the room in the winter. Stove provides heat to towel rails in two bathrooms, a heat-leak radiator in the linen cupboard and a 250 litre dual-coil hot water tank in the attic. 4 sqm Baxi Solarflo solar thermal panel system on south-facing roof for water heating.

**Ventilation:** Paul Novus 300 MVHR system, PHI certified to have a heat recovery rate of 94%

**Electricity:** 9 sqm Panasonic solar photovoltaic array (six panels) with average annual output of 1.5kW

**Green materials:** Locally sourced stone cladding, outbuildings and boundary walls rebuilt using stone recycled from the site, roof slates sourced from a demolition in Newcastle. Scrap timber from the build used to heat the house for a full winter.

*Phil Newbold initially calculated the space heating demand to be 18/kW/m²/yr using PHPP, but soon after his computer crashed and his PHPP file was lost. He was not aiming for passive house certification so decided not to start PHPP calculations again. 50mm of PUR insulation was installed in the services zone of the roof and walls in lieu of 50mm fibreglass on which his initial calculations were based.

# Sideways west cork house

## rests lightly on the land

Photos: Denis Scannell

This uncertified passive house on Ireland's south-west coast makes a striking-yet-sensitive architectural statement.

**Words: Lenny Antonelli**

Designing and building a landmark house for the ragged-but-stunning coast of West Cork is not easy. In such sensitive surroundings, many designers have built garish mansions, while others might have designed something plain and uninteresting.

But with this house near Castletownbere, built for his mother, architect Donn Ponnighaus has produced a dwelling that manages to make an architectural statement while sitting lightly in its surroundings, adding rather than subtracting from the landscape.

Donn's mother Ita Molloy — a doctor who spent much of her career working in Africa — is originally from Westmeath. She bought a cottage on the site in 1993 to use as a holiday home, and later decided to retire here. The initial plan was to renovate and extend the cottage, but the conversation quickly turned to creating something new.

"What I really wanted was a house within the surrounding countryside. I wanted a house built into the hill in the field overlooking the mountains and the sea. We have got just a fabulous view with the windows down to Bere Island and out to the sea and across to the mountains," Ita says.

In 2011 Donn left his job with an architectural practice in England, where he had learned about the passive house standard. The following year he moved to Castletownbere to work full time as architect and project manager on this job. But his work in England was mostly on big commercial projects. He says: "I'd never built a house. I thought: am I biting off more than I can chew?"

Donn's desire to reduce the house's environmental impact was borne from his childhood in Malawi, where he witnessed a daily struggle to obtain resources, and the knock-on effect of habitat destruction as forests were cut down for fuel and arable land.

"Architectural education teaches you that over 50% of energy used by humans is in the production and running of buildings so from then on I started feeling a personal responsibility," he says. "I always pushed for greater environmental design at every office I worked at, though I often ran head first into budget objections."

"There are many different aspects of building an environmentally friendly house but I knew very little about the energy side of things. It's simply not something you learn as an architect except in the most basic way."

Ita wanted the house to recede into the landscape, so it was decided to bury the ground floor in the hillside. This meant using a retaining concrete wall, for which Donn chose the Quad-Lock insulated concrete formwork system, which was erected by Fermanagh-based Passive Building Structures. For the sake of continuity and simplicity, Donn chose the same system on the first floor too.

"I could have put a timber frame on top, but I'm very aware that if a passive house fails it fails at the joints," he says. The ICF system includes a 200mm reinforced concrete core with 160mm of EPS externally and 80mm EPS on the inside. The polystyrene panels are erected in a Lego-like fashion, then the concrete is poured down in between to set.

Passive Building Structures also supplied a polystyrene roofing system, Passive Roof Panel, for the house, with 220mm EPS panels used for the building's vaulted ceilings. The panels were taped to a damp proof course embedded in the top of the ICF walls to ensure airtightness at a critical junction.

The morning of the air pressure test, the house yielded a good but far-from-passive result of 1.5 air changes per hour. It turned out the concrete in the ICF had not fully compacted in some places, meaning some patching up was needed. "We achieved 0.55 by the end of the day but it took four people all day finding the holes and patching them up." Donn says. ▶

“I knew very little about the energy side of things. It's simply not something you learn as an architect except in the most basic way.”

“Airtightness is the hardest thing to explain to people until they have experienced a pressure test themselves and seen how air gets in the smallest cracks. I think general builders are very good at understanding how water works and how to deflect it away but understanding that air is a gas and behaves quiet differently will need some more time,” he says.

The thermal envelope is completed with a raft foundation system insulated with 160mm of EPS below the slab. Meanwhile 60mm of EPS around the slab perimeter joins the outer EPS layer of the ICF walls, and 60mm of Kingspan polyurethane above the slab joins the inner EPS layer of the ICF walls. The whole house is effectively wrapped twice in insulation.

Meanwhile the windows are triple-glazed aluminium-clad timber Optiwin Alu2Wood units, manufactured in Wicklow by Ambiwood.

The house is primarily heated by a Nilan Compact P combined heat recovery ventilation and air-to-air heat pump system. This provides ventilation, air space heating (or cooling) and domestic hot water by utilising exhaust air from kitchens, utility and bathrooms. The conditioned air is then distributed by Nilair ducting to air supply grilles in the floors, while extract valves are in the ceilings. In this instance, the Compact P also includes a separate 3 kW Geo3 geothermal heating unit that draws on a horizontal ground loop in the garden.

In winter the system first recovers heat from warm exhaust air, while the geothermal unit can be switched on to support air space heating or domestic hot water. The Geo3 distributes to underfloor heating pipes in two zones: the thermostatically controlled bedroom, and the main living spaces, which feature weather compensated controls.

The Compact P has a central controller placed in the living spaces for ventilation, temperature and humidity, while the Geo3 has its own control. “it just feels great to be able to control it – the ventilation rate and the temperature control as well,” Ita says.

Maurice Falvey of Nilan Ireland, who designed and supplied the system, adds: “From Donn’s point of view it’s a retirement house, so it’s got to be maintained in a comfortable way. The unit is set up so that it will automatically go into cooling if it reaches 25 or 26C.”

Passive house newcomer Donn credits Falvey, a veteran of passive house projects in Ireland, for helping him through the process. The house, named Teach Maoldia after the Irish for Molloy, also features a room-heating Jydepjsen wood burning stove and Poujoulat airtight chimney system supplied by House of Heat, including an airtightness plate connected to the airtight membrane, beneath an additional insulation sleeve to prevent cold bridging where the flue penetrates the envelope.

But Donn’s attention to environmental issues extended beyond energy. A 5,000 litre rainwater tank provides toilet water, and Donn plans to ▸

(above and below) ICF was also used to build the party wall between the house's two sections. The insulation here was only needed as temporary formwork and a variety of different objects including fishing nets, bamboo, grass, leaves and sea shells were cast into the concrete; (p43) the house is divided into two living spaces, public and private, separated by a library wall with its own secret doors. A glass balustrade is yet to be installed; (p47) the house sits easily in its surroundings, with the ground floor receding into the hillside, whilst offering spectacular views of the sea and mountains.

upgrade this in future to meet all the house's water needs.

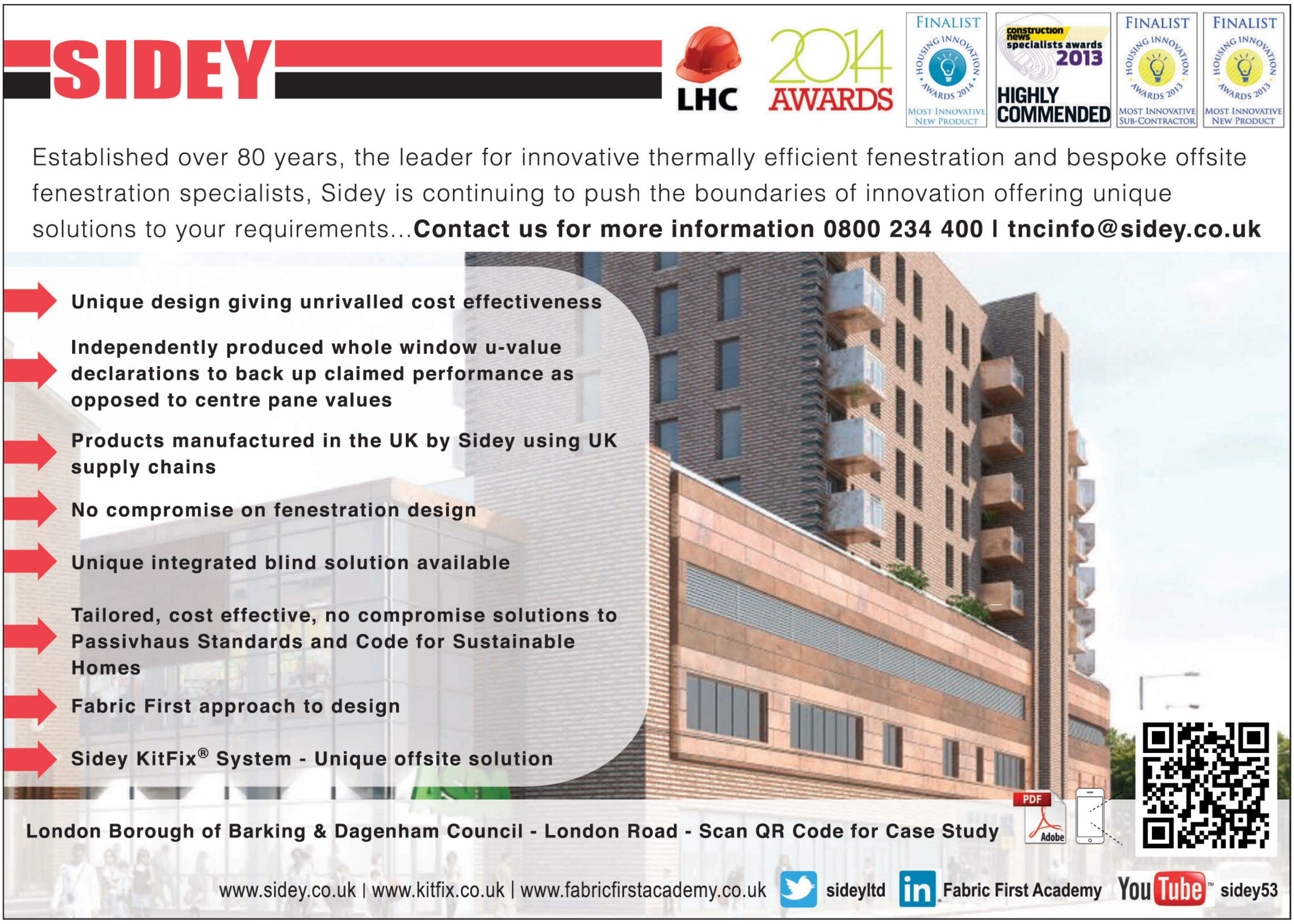
The house also has a Biorock gravity-based secondary wastewater treat system. Secondary treatment systems, which treat wastewater after it leaves a septic tank, typically use bacteria to further treat spillover. They normally use a pump to circulate water, but the Biorock unit can work off gravity alone because of the steep site.

Besides its environmental impact, good design is at the heart of Teach Maoldia. "The house has a lot of features that are normally associated with houses that have a much higher budget," Donn says. "This was possible because I could spend the time to design and build every detail to a very high specification even if it meant doing it two or even three times."

Most architects put public rooms downstairs — living room, dining room, kitchen — with the private bedrooms and bathrooms upstairs. But Donn took that layout and flipped it 90 degrees, creating two separate living spaces — a public one and private one — side by side, divided by a library with its own secret doors that houses Ita's vast book collection and forms a vertical wall between the two parts of the house.

The other unusual design feature is the artistic imprinting on the central inner wall, which was also constructed with ICF. Donn removed the insulation here (which exposes the concrete and provides more thermal mass too) and used stones, grass, leaves, bark, fishing nets, bamboo and other items to create imprint on the wall. Other internal concrete walls in the house feature similar imprints with bamboo, sea shells, and the leaves of various tree species.

What has Donn learned from the experience of building to the passive house standard, albeit without the third party oversight and confirmation that certification brings? He says designing a passive house in a rural environment — where there is no overshadowing from neighbouring buildings — is not difficult in itself. Teach Maoldia's biggest glazed elements face east, but reaching the passive house standard ▶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was still quite achievable.

On the other hand, he says project managing a passive house build is not so easy — he reckons it is still difficult for general contractors and tradesmen to appreciate the level of detail needed.

"I think self builders like myself can do it and large professional building contractors with lots of resources can project manage passive houses successfully, but middle of the road builders will struggle unless they specialise," he says.

"Sometimes I thought that I had bitten off more than I could chew as I struggled to build a house, let alone a passive house, but I am now incredibly happy that I set such a high target."

Donn's mother Ita and her husband Andrew fully moved into the house a few months ago. But in fact they had been living in the guest bedroom, which was completed first, since October. She says that even though there was no heating system during the winter, it was still much warmer in the new passive house than in the old cottage with its storage heaters and fireplace.

"It's worked out absolutely stunning," she says of her new home. "It's hard to describe, it is just wonderful. It is just a beautiful place to live in."

**SELECTED PROJECT DETAILS**
**Client:** Ita Molloy
**Architect:** Donn Ponnighaus
**M & Engineer:** Maurice Falvey
**Civil & structural engineering:** JJOS
**Airtightness tester:** Greenbuild
**Insulated concrete formwork, foundations & roof system:** Passive Building Structures Ltd
**Insulating concrete formwork supplier:** Quad-Lock
**Ground floor insulation:** Kingspan
**Windows & doors:** Optiwin by Ambiwood
**Heat pump & ventilation:** Nilan Ireland
**Chimney system:** Poujoulat, supplied by House of Heat
**Wood burning stove:** Jydepjsen, supplied by House of Heat
**Lighting:** Lucas LED
**Rainwater harvesting:** Glenview Heating and Plumbing
**Bathroom fittings:** Ideal Bathrooms

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## PROJECT OVERVIEW:

**Building type:** 184 sqm detached, two-storey house on sloping site. Main entrance at rear on first floor.

**Location:** Castletownbere, Co Cork

**Completion date:** June 2014

**Budget:** £300,000

**Passive house certification:** not certified

**Space heating demand (PHPP):** 15 kWh/m²/yr

**Heat load (PHPP):** 11W/m²

**Primary energy demand (PHPP):** 109 kWh/m²/yr

**Airtightness (at 50 Pascals):** 0.55 ACH or 0.662 m³/hr/m²

**Building Energy Rating:** pending

**Thermal bridging:** raft foundation insulated with 160mm polystyrene. Insulation brought up and around the toe of the raft foundation and joined with 160mm of external insulation on Quad-Lock ICF system. Internally 60mm of Kingspan polyurethane laid on top of raft foundation (underneath screed) and joined with the 60mm of internal Quad-Lock polystyrene. At roof level the concrete of the gables was kept down by 160mm and after concrete pouring the gap was filled with polystyrene.

Quad-Lock ICF ties are made from plastic and are recessed into the polystyrene by 20mm. The roof is made from 220mm deep polystyrene panels. They are 1.2m wide with MS channels running up the side. The channels are recessed 50mm so no steel is exposed on the outside of the roof. The internal plasterboard is glued on so no screws are used.

**Ground floor:** raft foundation insulated with Kingspan Aerobord EPS insulation – 160mm below the slab, and 60mm around the perimeter, with 60mm Kingspan polyurethane insulation above the slab. U-value: 0.136

**Wall 1:** slates, counter-battens (80mm), non-breathable roof underlay, ICF system (Quad-Lock) comprising 160mm polystyrene insulation on outside, 200mm reinforced concrete (airtight layer), 60mm polystyrene; 12.5mm plasterboard internally.

**Wall 2:** 8mm render, ICF system (Quad-Lock) comprising 160mm polystyrene insulation on outside, 200mm reinforced concrete (airtight layer), 60mm polystyrene; 12.5mm plasterboard internally

**Roof:** slates externally followed beneath by counter-battens (80mm), non-breathable roof underlay, 220mm deep polystyrene panels. (1.2m wide with MS channels running up the side), plasterboard (glued in factory). Panels taped to DPC embedded in top of ICF concrete walls. Foam filled between panels internally and externally. DPC on ridge taped to panels.

**Windows:** Optiwin Alu2Wood slim line windows. Triple-glazed aluminium clad timber windows. Overall U-value: 0.77.

**Heating :** underfloor heating linked to 3kW geothermal heat pump built into the Nilan Compact P exhaust air heat pump with heat recovery ventilation. Wood stove: 3-5 kW Elegance Junior by Jydepjsen with a Poujoulat airtight chimney system.

**Ventilation:** Nilan Compact P JVP 3

**Wastewater treatment:** Biorock: Secondary waste treatment using gravity. LED lighting used throughout.

# Modern Galway home

When work began on this low energy, super airtight project in Co Galway it faced a tight budget and a market for passive house products that had yet to mature. But in the end its owner Hugh Whiriskey emerged with a comfortable home with stunningly low annual heating and hot water costs of just over a euro per square meter.

**Words: John Hearne**

Hugh Whiriskey was planning for his Co Galway low energy build long before he began designing the house. First, he planted willow trees to meet his future fuel needs on an acre and a half behind the house.

"The theory is, we'll supply our own timber from it," he explains. "I tried to work out how much we'd need at the time and planted accordingly. It's three years down, so in a year and a half, we'll be cutting one third, and then replanting."

Heated by a combination of a geothermal heat pump and room-sealed stoves, Whiriskey also made provision for PV panels on the roof, which he expects to install down the line. Right now, with a full year's heating and hot water costing just €375, the additional capital cost is difficult to justify.

Whiriskey works with architects and consulting engineers Corbwell Design in Galway and drew heavily on the company's expertise when designing and building his own house. "The principal behind the company is to give a full service from planning through to construction, tender if necessary, project management and sign off, and we have a very strong emphasis on passive house principles." Whiriskey also runs the low energy building product company Partel.

Financial considerations lay behind the decision to go with masonry build. At the time, the meltdown in construction had seen the price of block laying decline sufficiently to make it that bit more cost effective than timber frame. An engineer by profession, Whiriskey went with a wide 250mm cavity pumped with EPS platinum bead. High ceilings and an open plan design also prompted the decision to lay blocks on the flat, giving a 215mm concrete wall. "So you're automatically getting a very high thermal mass," he explains. "The house retains its own heat at a very comfortable temperature."

Photos: Kelvin Gillmor

# delivers ultra low energy bills

He found however that the detailing required to ensure airtightness and design away thermal bridges was a lot trickier than it would have been with a timber frame. Luckily, local contractor Niall Dolan of GreenTec Eco Homes is a specialist in these areas. A veteran of several wide cavity builds, he supervised the project and worked through each airtightness and thermal detail to ensure a passive-standard building envelope. “Niall is brilliant on the details,” says Whiriskey, “he makes that side of things quite easy.”

Quinn Lite blocks were deployed at both foundation and wall plate level to deliver the necessary thermal break, while Teplo-Tie wall-ties in the cavity did the same job there. Ply boxes were used behind the windows to close the cavities, but it was detailing the balcony that took the most thought and energy.

“We were adamant we wanted to keep it ▶



(above) Though the building wasn't designed as a passive house, careful attention to airtightness using Ampack's range of tapes and membranes, with particular attention paid to key junctions such as windows, chased walls and a counterbattened service void in ceilings, leading to an impressive pressure test result of 0.48 ACH.

cantilevered, unsupported on the far corner," Whiriskey explains. "Structurally that makes things difficult, and then you've got to factor in the thermal bridging as well, so between those two, it consumed a bit of time."

Concrete upper floors are typically hollowcore; precast slabs are craned into place on top of blockwork, but because Whiriskey wanted an open plan layout downstairs, that approach would have involved large amounts of structural steel in the slabs, which in turn would have had a major impact on cost. Because he also wanted the first floor balcony to extend unsupported over the patio area outside, that too would have required large amounts of steel. This was a non-runner not alone from a cost point of view, but also because thermally breaking the structure would have been almost impossible.

The solution was to pour the upper floor in situ, and thermally break the cantilevered balcony using a specialised Schöck Isokorb balcony connector - available in Ireland via Contech Accessories - embedded in the concrete. This, says Niall Dolan, was unquestionably the most difficult element of the build. "The airtightness here wasn't too bad," he says, "but the balcony and the cold bridging for the poured slab, that ▶

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really was the trickiest thing."

Airtightness comes primarily from the internal wet plaster finish, together with Ampack's suite of tapes and membranes. "We plastered down to the slabs and put a little bevel on the plaster to seal it," says Niall Dolan, "we didn't need to use any tape at the bottom."

At the time Whiriskey was selecting a window and door package, the choice of passive components was limited. While triple-glazed windows were installed on other elevations, he opted to install a high performing double-glazed window on the south facing living areas. "On the pure energy side of things, you get a better thermal gain from double-glazing on south facing windows, so there was an energy balance to be made there." These double height windows are non-opening, and don't feature any additional mullions, features which give them a much better thermal profile.

The problem with working in the trade is that new products are always coming on stream, so you get a ringside seat for all the components and technologies you would have installed, if you were doing the job today.

"Today, you wouldn't question [using] the passive house standard windows and doors throughout," says Whiriskey, "but at the time, we did what we could within budgeting constraints. It's always a balancing act."

The Whiriskey family have been in the house now for a year, and so far, so good. "We're very happy with the build, very happy with the appearance, very happy with how the house is performing. On the whole, I'd say we're pretty fortunate with how it's worked out."

**Selected project details**
**Client:** Hugh Whiriskey
**Project management, M&E and civil engineering:** Corbwell Design
**Contractor:** GreenTec Eco Homes
**Mechanical contractor:** EIL
**Windows and doors:** True Windows
**Cellulose insulation:** Ecocel
**Wood fibre insulation:** Partel
**Floor insulation:** Kingspan
**Cavity wall insulation:** Eurobead
**Airtightness products & wall ties:** Partel
**Thermally broken balcony connector:** Schöck
**Thermal blocks:** Thermal Insulation Distributors Ltd
**Heat pump:** Unipipe
**Heat recovery ventilation:** Dimplex Renewables
**GGBS:** Ecocem
**Floor screed:** Egan Screeding

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## PROJECT OVERVIEW:

**Building type:** 350 sqm detached two- storey wide cavity masonry build

**Location:** County Galway

**Completion date:** June 2013

**Passive house certification:** N/A

**Space heating demand (PHPP):** 36 kWh/m$^2$/yr

**Heat load (PHPP):** 16 W/m$^2$

**Primary energy demand (PHPP):** 85 kWh/m$^2$/yr

**Airtightness:** 0.48 ACH at 50 Pascals.

**Provisional BER:** A2 (46.68 kWh/m$^2$/yr)

**Energy bills:** Annual running cost for heat and hot water projected at €375

**Thermal bridging:** Quinn Lite aircrete blocks used at foundation and wallplate; Teplo-Tie wall ties; Foamglas Perinsul under steel supports; Schöck Isokorb balcony connector used for cantilevered balcony.

**Ground floor:** Raft foundation insulated with 140mm Kingspan Thermafloor PIR insulation and 50mm perimeter Kingspan Thermafloor PIR insulation. U-value: 0.12

**Walls:** Sand and cement render on concrete block external leaf with 250mm cavity full filled with EPS platinum bead insulation. Concrete block inner leaf complete with airtight plaster. U-value: 0.12

**Roof:** Trocal & zinc on two staggered layers of OSB on battens for air flow, on Ampack Protecta plus membrane, on 225mm rafters with high density Ecocel cellulose insulation and Ampack Variable airtight Resano membrane. Service cavity with 50mm Schneider woodfibre insulation. U-value: 0.13

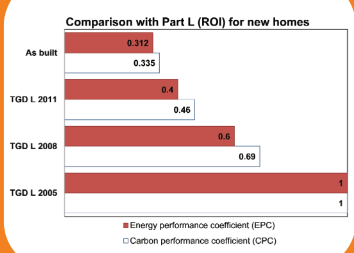
**Windows:** triple and double-glazed timber-aluclad Bug windows with U-values of 0.92 & 1.20 respectively

**Heating system:** Nibe 1245 ground source heat pump with underfloor heating. Thermostats in all rooms.

**Ventilation:** Xcel 400QVI mechanical ventilation with heat recovery. 91% efficient with summer bypass.

**Electricity:** planned 12 m$^2$ solar photovoltaic array with average annual output of 2kW

**Green materials:** Schneider wood fibre Insulation, cellulose Insulation, Ecocem low carbon cement used in floors, sustainably sourced native timber used throughout.




Photos: Gerard Conneely

# Traditional Irish cottage looks to the future

Despite its stop-start beginnings, this cottage in the west of Ireland delivers a traditional-but-stylish design with close-to-passive performance.

**Words: John Hearne**

This super low energy project, built on a remote site in rural Galway, almost didn't happen. Architect Lester Naughton explains that when the client bought an old cottage on the site, the initial plan was to extend it.

"Somewhere in the mix, they decided to demolish and start it new. They got the blockwork up to wall plate level and next thing an enforcement order arrived from the council. Someone had complained, and when the client went for retention on what had been built, that was refused."

It was at this point that Naughton got involved. Interestingly, the approach came through the Simon Open Door initiative. This is a joint venture between the Simon Community and the RIAI, where architects around the country offer a one hour consultation in exchange for a €50 donation to Simon.

A lengthy engagement with the planners finally resulted in permission to build an almost exact replica of the original cottage. "A house for a house," says Naughton. The one concession he secured was that two outbuildings which had also been knocked, could now be extruded a little further than before, and incorporated into the dwelling space.

"Visually," says Naughton, "it was much the same as what would have been there. I worked from limited photographs, and there was a survey that was done by someone earlier on that we took as a baseline."

Initially, he only set out to build to regulations, but a discussion about how the house might be heated raised the passive house concept. The idea appealed instantly to the client, who preferred not to be identified for this article.

"First and foremost," she says, "I'm a cold person and being miserably cold in the west of Ireland wasn't an attractive proposition." She also cites the rising cost of fuel, the beauty of the location and the environmental imperatives as motives behind the drive to go passive. "Also, it's on the side of a hill along a very narrow road that isn't well maintained by the council. Between the prospect of running out of oil, and even just having to store oil in a place like that, it just didn't seem like the right thing to do."

Naughton got in touch with passive house experts MosArt in Wicklow, who supplied consultancy on the build. He also completed one of MosArt's passive house design courses.

Straightaway, it became clear that this would not be a straightforward project. Stringent planning conditions meant that there was only so much that could be done to realign glazing and adapt the design to best suit passive house. On the upside, the house was already oriented towards the south.

"Things like solar gain weren't invented yesterday," says Naughton. "There was one little window that faces north and that was more or less there anyway." But while those traditional forms – cottage and shed, tied together by a glazed element – found favour with the planners, they did create a number of headaches, not least trying to get airtightness down to passive standards.

Contractor Peter Wall hadn't attempted a passive build before, which meant that he and his team faced a steep learning curve. "It was a tough house to do," he says, "and not that it was a big house but the design of it; it was almost divided in two. If you had a house with four corners, it would have been much simpler. So it was very painstaking, you couldn't rush it."

When Peter's team began work on the existing walls, they found that they were not up to standard, so the decision was taken to demolish, leaving them with just the existing slab. Naughton liaised with MosArt in drawing up details to deal with thermal bridges. It was decided that the slab would now be treated as a base layer, on which 350mm of Xtratherm PIR was installed. This insulation was then extended up the inside of the external walls at a thickness of 100mm and below the rafter line at 75mm to create a continuous insulating layer. The 100mm cavity itself was pumped with bead.

In order to minimise thermal bridges, internal walls were cut back at the point where they met the external walls, to allow a continuous layer of both insulation and air tightness membrane. In the same vein, ridge beams were finished to the inner leaf to prevent breaking ▶

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the insulated seal.

The first blower-door test returned a result of around one air change per hour. Subsequent improvements to some of the weaker elements brought that figure down 0.82 ACH. At that stage, the project had overrun its completion date by several months, and the client decided that rather than push for the passive standard of 0.6 ACH, she would take the hit and complete the project.

"You're very much up against it with a building that has a lot of surface area to floor area," says Naughton. "If I had a 200 square metre two-storey house in a cubic form there would be that much more forgiveness."

The client, who uses the house as a base when she's in the west, moved in two years ago. She pays tribute to the knowledge of the architect and the workmanship of the contractor. "I have to say I absolutely love it," she says. "I'm constantly delighted I made the decision I made to bring it up to passive. It's the comfort levels, just the fact that the weather can be doing whatever it likes outside, it's always perfect inside."

## PROJECT OVERVIEW:

**Building type:** 102 square metre detached house on a rural site

**Location:** County Galway

**Completion date:** November 2011

**Space heating demand (PHPP):** 16.1 kWh/m²/yr

**Heat load (PHPP):** 14 W/m²

**Primary energy demand (PHPP):** 72 kWh/m²/yr

**Airtightness:** 0.82 ACH, 0.77 m³/h³/m², both at 50 Pa

**Energy performance coefficient (EPC):** 0.373

**Carbon performance coefficient (CPC):** 0.398

**BER:** A3 (74.53 kWh/m²/yr)

**Thermal bridging:** due to planning constraints the building retained an existing foundation slab so thermal bridges were avoided with an internal line of insulation around the structure. 350mm of PIR insulation was placed over the existing slab returning up the inside of the external walls 100mm thick and below the rafter line 75mm thick, all forming a continuous line. Where internal walls extended to the existing foundation slab they were in Quinn-lite B3 blockwork. On external walls the internal line of blockwork was kept back and 50mm of PIR board was returned across the cavity. Internally insulated plasterboard was returned into the windows so as to overlap the window frames and reduce thermal bridging as much as possible. Thermal bridges were not calculated but judged to be thermal bridge free (at least as relevant to PHPP calculation methods). For the purposes of DEAP the details were assessed as being equivalent or better than the Irish accredited construction details.

**Ground floor:** 100mm screed on 350mm PIR insulation on existing structural slab. U-value 0.06 W/m²K (0.080 W/m²K when not adjusted for ground effect).

**Walls:** 200mm stone or plaster finish externally on 100mm concrete block wall with 100mm blown (grey) bead insulation to cavity, 100mm Quinn-lite B3 block interior wall followed by 100mm Xtratherm Thin-R PIR insulation. Isover Vario airtightness/vapour control layer followed by 75mm deep battened wall services zone filled with Isover Metac mineral batt Insulation. Plasterboard and gypsum skim finish. U-value 0.093 W/m²K

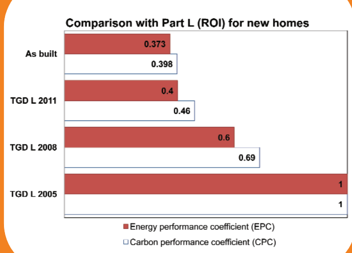
**Pitched roof:** Natural Stone Slates on 50x35 Battens and counter battens on Tyvek Supro plus sealed roof membrane on 75mm Xtratherm Polyiso board on 175x44 (or 150x44) Rafters at 400 crs with 150mm Xtratherm Thin-R PIR insulation board between rafters and 75mm Xtratherm Thin-R PIR insulation board below rafters. Isover Vario Airtightness line/vapour control layer followed by 50x50 battens forming services zone filled with Metac Batt insulation. Plasterboard and gypsum skim finish. U-value 0.083 W/m²K

**Flat roof:** Sarnafil G waterproofing membrane system on 18mm wbp ply on battens firred to 1:50 fall. 100x44mm rafters at 600crs with 100mm Xtratherm Thin-R PIR insulation board between rafters 50mm ventilation zone maintained over rafters with additional 50mm Xtratherm Thin-R PIR insulation where battens are over 100mm deep. 50mm Xtratherm Thin-R under rafters with Isover Vario membrane to the warm side. 35x50mm counterbattens at 400mm centres with 35x50mm counterbattens at 600mm forming services zone. Services zone and all irregular voids filled with Isover Metac mineral batt insulation. 32.5 mm insulation-backed plasterboard internal lining. (not foil backed) U-value 0.114 W/m²K

**Windows:** Nordan Ntech windows. Triple-glazed with argon fill and low E coating. Thermally broken timber framed windows with aluminium external cladding. Overall U-value 0.92 W/m²K (calculated average). Solar factor (g): 0.5

**Heating system:** Dimplex LA11MS air to water heat pump. SPF: 333%. Heating 210 litre water tank with underfloor heat delivery.

**Ventilation:** Paul Novus 300 heat recovery ventilation unit. Passive House Institute certified to have heat recovery rate of 93%.




**SELECTED PROJECT DETAILS**
**Architect:** Lester Naughton Architect
**Civil & structural engineering:** Williams Johnson & Associates
**Contractor:** Peter Wall Construction Ltd
**Mechanical contractor:** Ollie McPhillips Building Services Ltd
**Airtightness tester:** Energy Matters
**Rigid insulation:** Xtratherm
**Mineral wool batts, airtightness membranes & tapes:** Isover
**Windows & doors:** Nordan Ireland
**Aircrete blocks:** Quinn Lite
**Air to water heat pump:** Dimplex Renewables
**Heat recovery ventilation:** Pure Renewable Energy

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(below, l-r) In addition to an insulated cavity, the wall build-up includes 100mm Xtratherm PIR insulation; beneath the Isover Vario airtightness system, a 75mm service void; filled with Isover Metac mineral batt insulation.

# Ireland's 1st hemp-built passive house

For self-builder James Byrne, building to the passive house standard was just one element of an approach that aimed to drastically reduce the environmental impact of his house — built from a hemp and lime system, it also features solar collectors, rainwater harvesting and natural wastewater treatment.

**Words: Lenny Antonelli**

For this uncertified passive house project in rural County Longford, Ireland, self-builder James Byrne pushed the sustainability boat out about as far as he could. Not only does the house hit passive house targets for heating demand, it's built with hemp-lime, heated with waste timber from the construction and features a reed bed wastewater treatment system and rainwater harvesting.

"I was born on a farm and have always had an interest in the rural environment. While I lived in towns and cities for many years, this interest in a rural life for my family was what lead to our decision to move back to Longford and to build this house," he says. He was also concerned about climate change and wanted to support efforts to build a low carbon economy. "I had a unique opportunity to build something special and that's what I set out to achieve."

Good design was also key to James, who has used some of architect Christopher Alexander's design patterns in the house. Alexander is a proponent of the idea that users know more about what they want from buildings than architects.

James says: "Architects should be more like a conductor where they work with the client to extract the design from them. Most clients know what they want but they don't know how to describe it or how to put it together into a workable design. This is where an architect can add real value."

Passive House Plus's predecessor magazine Construct Ireland previously published a short article on this project as it was nearing completion. But we decided to go back now to find out how the house has functioned in practice, and what lessons James has learned.

Keen to use a green material and to build the house himself, he chose the Tradical Hemcrete system from Lime Technology. Tradical deliver the hemp shiv (the woody core of the plant) to site along with the Tradical HB lime binder. These are then mixed with water and poured into timber-shuttering against the timber frame structure (which was built here by A-Frame). "It's pretty idiot-proof," James says. The system provides both insulation and structure.

James tested the system first by building a garage, which also now includes a home office. The build-up of the house is finished inside and out with Baumit lime renders. The monolithic wet-plastered nature of the system helped to provide airtightness — the house got under 0.6 ACH on its first blower door test. Byrne also says the high thermal mass of the hemp-lime is great for buffering heat — absorbing it and then releasing it out to the rooms slowly.

Continuing the theme of environmentally sensitive materials, the roof is insulated with cellulose.

Meanwhile the Passive House Institute certified insulated slab, designed and supplied by Viking House with Cavan-based EPS manufacturer Airpacks, features 40% Ecocem ground granulated blastfurance slag, a low carbon alternative to cement.

James has heated the house — which is on the large side at 335 square metres — with leftover construction timber since moving in, and reckons he has enough wood for one more winter. He burns it in a 78% efficient ESSE wood-fired cooker with a back boiler, which — along with five SolvisCala solar thermal collectors — feeds into his 950 litre thermal store. This then supplies space heating via a water-to-air heat-exchanger in the Paul heat recovery ventilation system.

Having such a big thermal store is essential for providing hot water to five kids, he says. In the shoulder months it also means that, if sunny weather does come around, there's enough storage capacity so there's still hot water leftover on the cloudy days that inevitably follow. The house also has a standalone 4kW room-sealed stove.

Rainwater harvesting supplies water to showers and two WCs. James also has a waste-separating system that composts solid waste and sends liquid to be treated by a vertical and horizontal reed bed system, which was designed and supplied by Reed Beds Ireland.

Inspired by his self-build, James trained as a passive house consultant, and went on to build one more hemp-lime house in Galway. But he returned to working in web development as the construction industry in Ireland flatlined.

However, he told Passive House Plus he's now investigating possible ways to combine his passive house and web development expertise, perhaps by creating an online platform to aid those designing and building passive houses.

The house was designed by leading Irish green architect Zeno Winkens. Zeno had built with straw bale before, but never hemp. He points out that self-build projects like this will now become virtually impossible under the latest version of Ireland's building control act, which will require that all builders be registered professional contractors.

"If the right person came along I would recommend [hemp lime] to them, probably even more so than straw bale, because it is like concrete. Once you get the shuttering and the detailing right...it's just goes up and then you plaster it and that's it," Zeno says. Plus hemp-lime is less at risk of being damaged by moisture than straw bale.

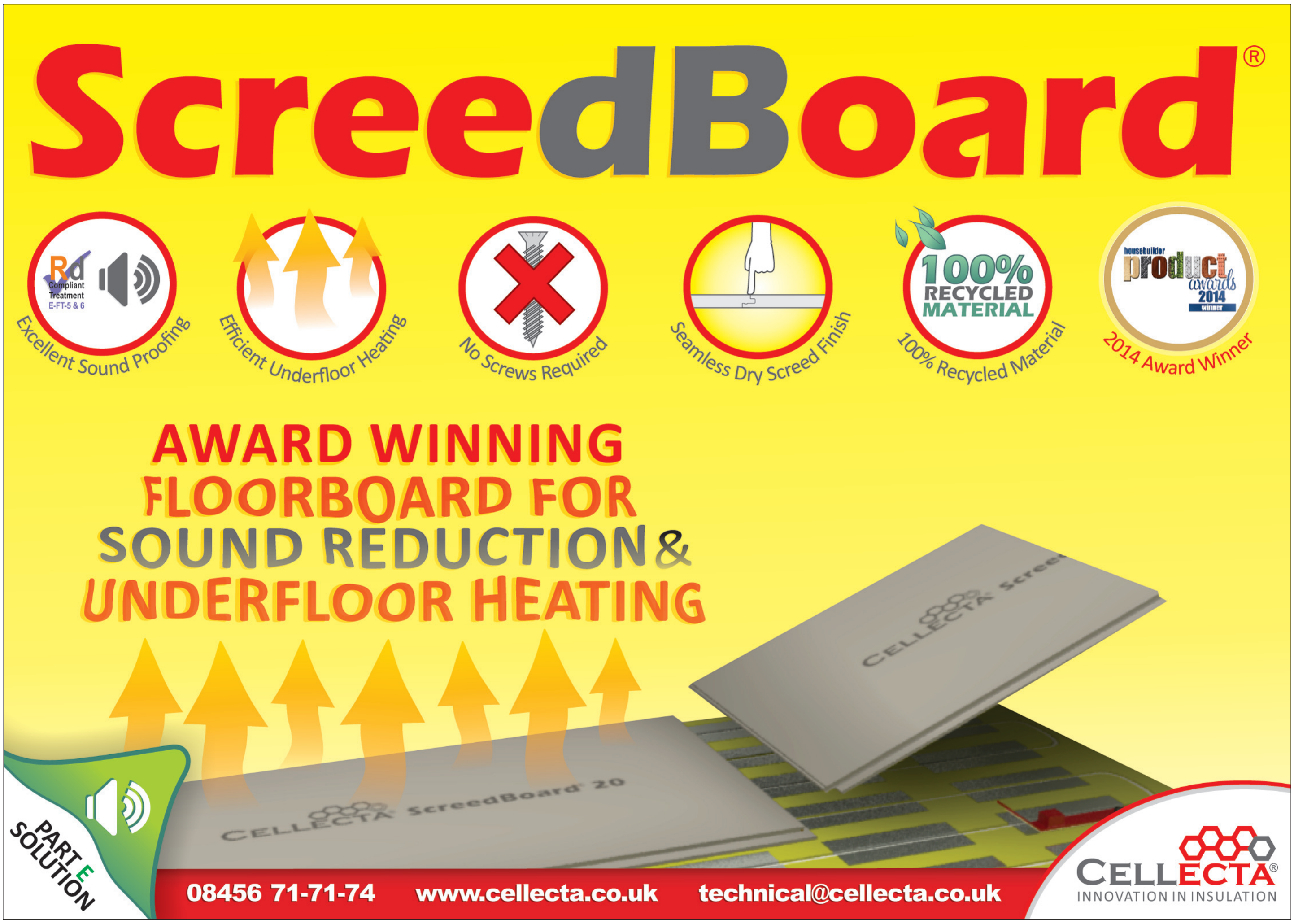
The house won the award for best residential project at the 2012 Irish Green Awards. But what has James learned about building a passive house? He says that because in winter he relies more on the immersion for heating water (for example if the cooker isn't lit and the solar thermal isn't generating much), plus an electric heater for his home office, his electricity bills are higher than he'd like. But he adds: "The house itself I'm perfectly happy with, it's great."

He offers advice for success on ambitious low energy projects. "Building is a learning process and you have to accept that no matter how much time or money you spend on it, there will be things that will bug you after it's finished and which you would like to change," he says.

(top) the perimeter of the foundation is wrapped in an insulated ring beam with the enclosed area filled with 300mm platinum EPS 100; (above and below) the Tradical Hemcrete is mixed on site with water and poured into timber-shuttering against the timber frame structure; (p61) (top and bottom right) the house is finished with Baumit lime renders internally and externally; (bottom left) the Hemcrete is cast to cover the front of the window and door frames.

He believes that more collaborative approaches to construction are needed — at all stages from design through to construction — particularly for ultra-detailed buildings like this.

He adds: "Take ownership of the project and employ professionals and trades who you can work with and trust. Delegate as much of the project as you feel comfortable with but never ▶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## PROJECT OVERVIEW:

**Building type:** 335 square metre detached two-storey hemp-lime house

**Location:** Abbeyshrule, Co Longford

**Completion date:** December 2011

**Budget:** €400,000

**Passive house certification:** uncertified

**Space heating demand (PHPP):** 15 kWh/m²/year

**Heat load (PHPP):** 10 W/m²

**Building Energy Rating:** pending

**Airtightness:** 0.53 ACH at 50Pa

**Energy bills:** no space heating bills yet – the building has been heated to date with leftover timber from the build

**Thermal bridging:** Window-to-wall interface: the timber frame is located on the internal side of the external walls and all windows and external doors are fixed back to the frame. The Tradical Hemcrete is then cast such that it covers the front of the window and door frames. The timber frame does not penetrate the Hemcrete walls; wall-to-roof interface: a parallel chord roof truss was chosen, the top rafter is a thermal bridge and so separating it from the bottom rafter minimises the thermal bridge while also providing sufficient space for the roof insulation; wall-to-foundation interface: the timber frame sits on the inside edge of the insulated ring-beam. This allows efficient transfer of all loads from the building into the insulated ring beam while ensuring that the Hemcrete connects to the foundation insulation.

**Ground floor:** insulated ring beam (Passive House Institute certified slab from Viking House & Airpacks) with 300mm platinum EPS100. U-value: 0.096 W/m²K

**Walls:** Factory-built 38x140mm @600ctrs timber frame with 2mm Baumit SEP02 render externally, followed inside by 15mm Baumit FL68 base coat, 450mm Tradical Hemcrete, 9mm Resistant Multi-Pro magnesium silicate board, 4mm Baumit MC55W and 2mm Baumit KalkGlätte G30 skim coat internally. U-value: 0.155 W/m²K

**Roof:** Bangor Blue slates externally on 50x35 battens/counter battens, followed underneath by 18mm Hunton Undertak bitumen impregnated woodfibre sarking board, 450mm parallel chord roof truss filled with cellulose insulation, 18mm taped & sealed OSB3, 125mm uninsulated service cavity, 10mm Fermacell ceiling. U-value: 0.093 W/m²K

**Windows:** Optiwin by Freisinger Alu2Wood triple-glazed aluminium-clad windows, with argon filling and an overall U-value of 0.78 W/m²K

**Heating system:** 78% efficient ESSE wood-fired cooker and five SolvisCala solar thermal collectors supplying 950L SolvisMax thermal store supplying air battery heater (water-to-air heat exchanger). 4 kW HWAM inset stove, room sealed.

**Ventilation:** Paul Santos 370DC heat recovery ventilation system. Passive House Institute certified to have heat recovery rate of 84%.

**Green materials:** Tradical Hemcrete, Resistant Multi-Pro magnesium silicate board, Fermacell dry lining board, cellulose insulation, 40% GGBS cement in foundations, Biofa paints.

James has heated the house — which is on the large side at 335 square metres — with leftover construction timber since moving in, and reckons he has enough wood for one more winter.

give up control. After all you have to live in the finished house. Build the best you can afford in terms of design, comfort and efficiency and try and ensure that it's adaptable to your future needs."

Sound advice from someone who, in terms of materials, has built what must be one of the most ecological passive houses around.

**SELECTED PROJECT DETAILS**
**Client:** James Byrne
**Architect:** Winkens Architecture
**Civil & structural engineering:** Carraig Consulting, Tim Kelly Consulting Engineers
**Project management, self-builder, passive house consultant:** James Byrne
**Mechanical contractor:** Alan Harrington
**Timber frame:** A-Frame
**Hemp & lime build system:** Lime Technology
**Roof insulation:** Cosycel
**Floor insulation:** Airpacks
**Windows:** Optiwin by Freisinger
**Airtightness products:** Proline Hardware
**Wood-fired cooker & stove:** Kildress Plumbing Suppliers
**Solar thermal:** GoSolar
**Heat recovery ventilation:** Pure Renewable Energy
**Airtightness tester:** Greenbuild
**Passive foundation system:** Viking House & Airpacks Ltd
**Reed bed system:** Reed Beds Ireland
**Lime renders:** Baumit
**Ecological paints:** Biochrome
**Magnesium silicate board:** Tradewood
**Electrical contractor:** Niall Smith

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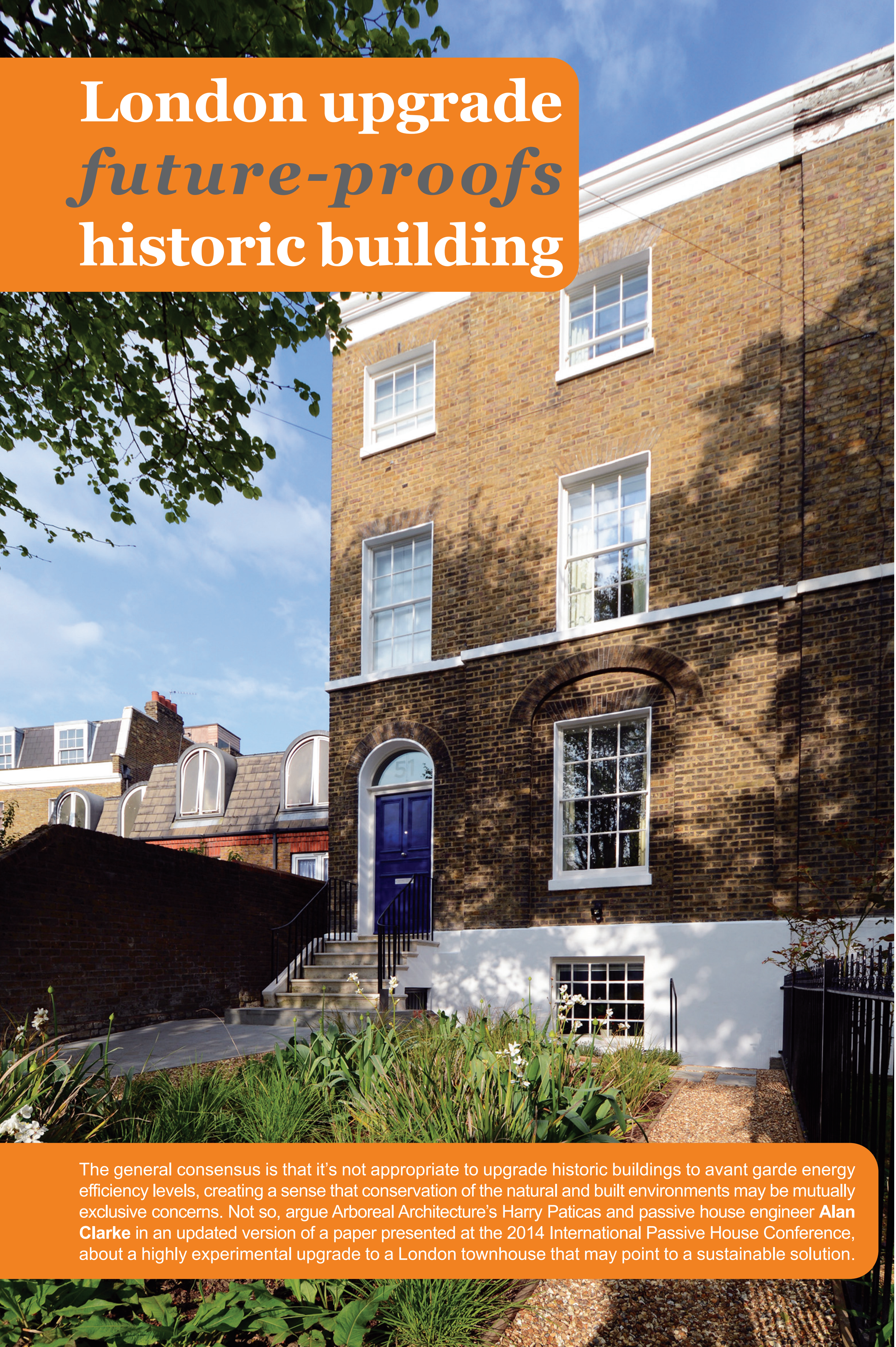
# London upgrade *future-proofs* historic building



The general consensus is that it's not appropriate to upgrade historic buildings to avant garde energy efficiency levels, creating a sense that conservation of the natural and built environments may be mutually exclusive concerns. Not so, argue Arboreal Architecture's Harry Paticas and passive house engineer **Alan Clarke** in an updated version of a paper presented at the 2014 International Passive House Conference, about a highly experimental upgrade to a London townhouse that may point to a sustainable solution.

Photos: Arboreal Architecture

Historic buildings present a range of challenges when carrying out improved energy efficiency. These include establishing an appropriate energy performance target, achieving approvals from the planning authority, designing bespoke solutions for internal insulation or airtightness, ensuring high levels of workmanship on site and ensuring that the long-term hygrothermal performance of the building fabric is not adversely affected by the thermal upgrade.

This paper reports on the design approach taken to insulation and airtightness for a 170 year old, listed, townhouse in London. Working within the constraints of the conservation requirements and existing building fabric nine different insulation materials were used in the project —- each a bespoke solution to localised performance requirements. Prior to the application of internal insulation, remote sensors were installed into the walls of the building with the aim of monitoring the hygrothermal performance at each location.

Construction commenced in February 2013, the building sensors were installed in June 2013 and the client moved into the house in November 2013.

**The existing building**

The four-storey semi-detached house has a total floor area (TFA) of 170 sqm and has a relatively low heat loss form factor (external surface area/TFA) of 2.22 due to the shared party wall. The external walls are built of London stock bricks with varying wall thickness: 495mm (two bricks) on the lower ground floor, 330mm (1.5 bricks) on the ground and first floors and 225mm (one brick) on the 2nd floor. The external walls face west (front), north (side) and east, (garden), with the party wall to the south.

The grade II listing and conservation area status of the house precluded the application of external insulation and replacement of the existing single-glazed, vertical sliding sash windows. The internal historic features include plaster cornices and decorative timberwork (shutter boxes, picture rails, timber skirtings, etc.).

**Setting an appropriate performance standard**

The initial ambition for the project was to achieve the Enerphit standard which has limiting values of 25 kWh/m$^2$/a for space heat demand and an airtightness of one air change per hour. Following discussions with the conservation officer it was established that external insulation and replacement of existing windows would not be permitted hence the Enerphit standard could not be met. At this point the AECB silver standard (a self-certification scheme using PHPP) was identified as a more achievable, though still challenging, target given the planning constraints. With a required space heating demand of 40 kWh/m$^2$/a, this would still represent up to 75% reduction in energy based on the PHPP modelling of the existing building (which had a space heating demand of 180 kWh/m$^2$/a before the retrofit). With a measured final airtightness of 2.1 ACH it is expected that the space heating demand target will be met and the project will achieve the AECB Silver Standard.

**Pre-design investigations**

At the outset of the project it was decided to carry out an assessment of the existing building performance. In February 2012, the company Archimetrics were appointed to carry out an airtightness test, thermographic survey, U-value measurement and interstitial moisture monitoring. The results revealed an airtightness of 9.6 ACH, significant leakage around openings and floor voids and a significantly lower U-value for the solid brickwork walls than predicted using standard thermal conductivity figures for brickwork. These investigations allowed a "finer grain" of design and specification to be carried out for the thermal upgrading of the house and provided additional assurance to the conservation officer that a holistic assessment of the impact of the proposals had been undertaken.

**Insulation specification**

Each of the nine insulation materials installed in the building were specified after consideration of the following key factors: permeable/impermeable thermal element, location in plan (orientation/internal layout), presence of historic timber and plasterwork, reversibility of installation, specific vapour performance of insulation (capillarity, vapour permeability and hygroscopicity), specific thermal performance of insulation (low lambda values), cost, and buildability. Table 1 summarises the range, location and U-value of each insulation material installed.

The lower ground floor and walls have a vapour impermeable construction due to an installed drained dry-lining system whereas all remaining walls and ceiling have varying degrees of vapour permeability. All internal walls were replastered with approximately 15-20mm thick vapour permeable natural hydraulic lime plaster with an alkaline pH (8-9) in order to maintain permeability and reduce risk of mould growth. The majority of external brickwork was repointed with a natural hydraulic lime mortar mixed with a waterproofing admixture (Stormdry Repointing Additive No.1) to reduce the absorptivity of the mortar joints. The external brickwork was not treated with a masonry hydrophobising impregnation (as recommended by material suppliers) due to resistance from the conservation officer and the results from an in-house masonry permeability report, which revealed that while the mortar joints were highly absorptive, the existing brickwork faces have a low absorptivity.

Where historic plaster cornices remained, the gypsum-face lime plaster was removed from walls and a bespoke depth (10/20/30mm) of Aerogel-backed magnesium silicate boards were applied over new lime plaster to retain the original profile of wall-to-cornice. Where there were 200mm deep empty stud walls on the west elevation either side of the shutter boxes, a full depth of woodfibre insulation was installed.

As a precaution against the risk of adverse effects of high levels of moisture in the walls, all timber buried in masonry (such as joist ends) was treated with a boron wood preservative paste. This paste diffuses into timber at moisture levels of around 20%. To further protect against high moisture levels, the area of wall between joists was plastered with natural hydraulic lime and insulated with Calsitherm calcium silicate board which is highly capillary active.

**Airtightness and ventilation specification**

The continuous air barrier to the house was formed by the application of a natural hydraulic lime plaster on all walls. Joist ends and door/window frames were all sealed with Pro Clima tapes, service penetrations with Pro Clima grommets, and the second floor ceiling with a taped Intello Plus intelligent membrane dressed into walls with plaster ceiling tape.

A continuous mechanical extract ventilation (MEV) system was installed with local fans in ▶

| Material | Product name/supplier | Depth (mm) | Floor | Location | U-value (W/m2k) |
|---|---|---|---|---|---|
| Rigid thermoset plastic | Kingspan K17/K18 | 180 | LG | W & E walls | 0.11 |
| Blown cellulose | Warmcel 500 | 270 | 2nd | Ceiling | 0.15 |
| Aerogel (int) Styrofoam (ext) | Kingspan Styrozone N300R | 30 + 140 | LG | N wall | 0.15 |
| Woodfibre | Gutex Thermoroom | 200 | G & 1st | W wall | 0.16 |
| Vacuum insulated panels | Kevothermal | 30 | LG | Floor | 0.25 |
| Calcium silicate board | Calsitherm | 150 | LG-2nd | Floor joists | 0.3 |
| Aerogel | Thermablok (Aerogel blanket and magnesium silicate board) | 30 | 1st-2nd | W & E walls | 0.32 |
| iQ therm | Remmers | 50 | G & 2nd | N wall | 0.38 |
| Aerogel | Thermablok | 20 | G-2nd | W, N, E walls | 0.41 |
| Perlite beads | Perlite Silvapor | 30 | G-2nd | Stair stringer | 0.58 |
| Aerogel | Thermablok | 10 | 1st & 2nd | W & E walls | 0.58 |
| Foam Glas | Technopor Glas Foam -Ecostrata | | | North wall external | |

each of four kitchen/wet rooms, extracting a total of 0.4 air changes per hour. Air intake is primarily through the natural leakage of the building. This strategy has the added advantage of ensuring that warm moist air is pulled away from the fabric and out through the fans.

The final air pressure test, carried out by Jennings Aldas, resulted in measured values of 1.7 ACH (co-pressurised with neighbour) and 2.1ACH (without co-pressure test) – an improvement factor of five times the original value.

**Monitoring data from sensors**

In May 2013, midway through construction works, 15 wireless sensors were installed into the building – four sensors measure ambient conditions on the inside, outside, cold loft space and sealed chimney flue, while the remaining eleven sensors were built into the masonry structure. In order to obtain data representative of existing timbers buried into the masonry walls, each sensor was mounted onto a small block of timber (Douglas Fir to match original) with a 10mm layer of lime mortar over. This junction of the inner face of masonry and internal insulation is the most likely place for a dew point to occur. The timber to which each sensor is fixed equilibrates to the moisture content of the surrounding masonry and provides the following readings: measured moisture content of the timber (WME), sensor temperature (T), relative humidity (RH) and absolute humidity (AH). Data from each sensor is continuously transmitted to a gateway connected to the internet and both live and historic information can be accessed from a server.

**Initial results**

Data has been collected from the sensors from mid-May 2013 to mid-January 2014. The internal ambient conditions since the client moved in in mid-November have been a stable temperature of 20C (± 0.5C) and a relative humidity of 53%(± 3%). These indicate a low internal moisture load most likely due to the low occupancy and MEV system ensuring continuous ventilation.

The general pattern recorded by the sensors since installation in May 2013 shows initially

| Sensor | Orientation | Floor | Insulation | U-value (W/m2k) |
|---|---|---|---|---|
| 3 | West | Ground | Woodfibre (200mm) | 0.16 |
| 8 | West | 2nd | Aerogel (30mm) | 0.32 |
| 9 | North | Ground | Aerogel (20mm) | 0.41 |
| 7 | West | 1st | Aerogel (10mm) | 0.58 |

high WME readings (25-35%) due to wet plaster, then a gradual drop in readings as the plaster dries out, then from October 2013 – January 2014 a steady rise in WME. For the purposes of this study the data from four sensors located in the west and north walls will be studied in detail – these are summarised in table 2 in order of increasing U-value.

**Relative humidity and WME**

As the graph shows, by the time the client moved in to the house in mid November 2013 the measured RH values were all in the range of 80-95% -- above the generally accepted threshold of 80% although it should be noted that this threshold value primarily refers to the water activity of interior surfaces[1]. The critical upper threshold for the prevention of frost/mould damage to internal adhesive, plaster & timber within a wall is 95%, though this is temperature and material dependent. The RH data reveals that there is a clear correlation between the U-value and RH — the lower (ie better) the U-value the higher the RH. As expected, the higher the thermal resistance of the insulation the lower the temperature of the brickwork – such observations have led to recommendations to limit U-values of internally insulated walls - in some cases to less ambitious levels than 0.27[2].

It can also be seen that that the north wall (sensor 09) maintained a reasonably steady level of humidity throughout the winter, when all the west wall sensors showed increasing humidity (in particular through November 2013), despite starting drier than the north wall at the end of summer. The likely reasons for the high levels of RH include the following: driving rain on west elevation; historically October, November and December are the wettest months in the year; the RH levels were already high before the wet winter months started.

Generally accepted guidance values for WME readings suggest that timber is safe (air dry) at values up to 15% WME, is at risk between 15-20% and is considered damp and at greater risk at above 20%. The interior ambient WME readings show values in the range of 11-13% from October to January which was as expected. Prior to the client moving in the WME readings of sensors in the walls were all above the safety threshold of 15%, ranging from 17-30%. The WME values steadily rose throughout the winter before falling to 15-17% since. The high initial readings therefore represent a combination of construction moisture with additional moisture loading from driving rain.

**Conclusion**

The data collection has revealed correlations between moisture content/U-value and between moisture content/orientation – generally higher levels of moisture have been found on west facing walls with lower (ie better) U-values. This should however, be qualified by the fact that two different types of insulation material (Aerogel and woodfibre) are compared and that the masonry wall thickness varies on each floor. The initial moisture content of the construction was significantly higher than normally assumed as a starting condition for Wufi calculations. Therefore, it is likely that the construction may take several years (two to five) before reaching equilibrium and any firm conclusions can be made. Although there were high RH readings for each sensor throughout winter, in particular sensor 03, the high density and capillary active nature of the woodfibre has a propensity to pull moisture away from the wall and retain a high volume of water within its structure. The woodfibre adhesive (and lime plaster) is also capillary active and due to its high pH is mould-inhibiting.

As further data is collected over the next few years specific attention should be paid to the RH and WME readings which reflect the likely conditions experienced by timber bedded into the external

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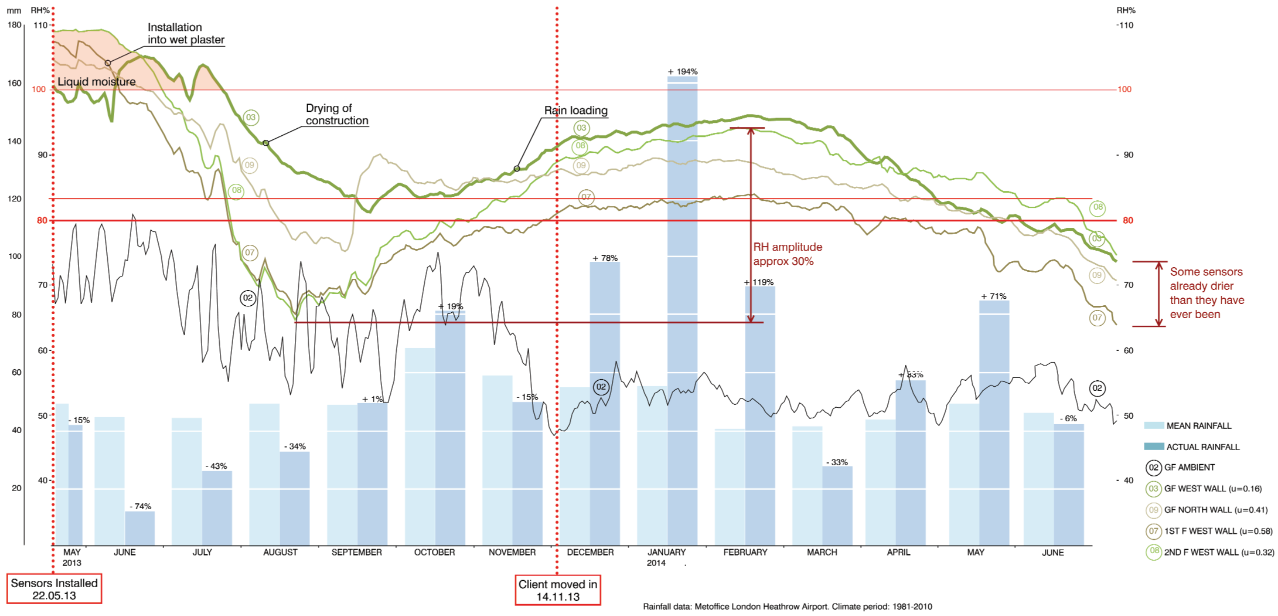
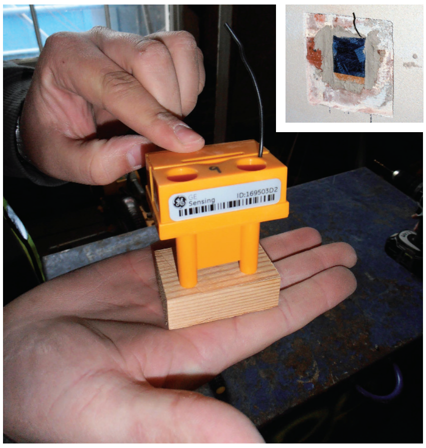
## 08_RESULTS FROM SENSORS_RELATIVE HUMIDITY




Harry Paticas - Arboreal Architecture

July 2014



walls. If high readings return then the application of a hydrophobising impregnation should be considered in order to further reduce the absorptivity of the brickwork and thus moisture uptake by the wall.

Relative humidity levels peaked in February, since when rapid drying has occurred to all four of the sensors studied – this is clear evidence that the wall constructions (masonry, plaster, insulation, paint, etc) are vapour permeable. Each sensor (as of 1 August 2014) is now recording the lowest relative humidity and wood moisture equivalent values it has had since installation into the building. With constant internal RH values of 50-55%, the high levels of RH in the walls over the winter period can be explained by both rain loading and a high level of construction moisture. For the four sensors studied RH values are now in the range of 59-70% and WME values now in the range of 15-17% with a clear trend of ongoing drying.

**Acknowledgements**
The authors would like to firstly thank their clients for their commitment to the project. Thanks also go to the AECB (Andy Simmonds) for organising and supporting the Omnisense Remote Monitoring Scheme, Joseph Little (Building Life Consultancy), Niall Crosson (Ecological Building Systems) and the main contractor (Noble & Taylor) for dedicating significant resources to the project.

**SELECTED PROJECT DETAILS**
**Architect:** Arboreal Architecture
**Contractor:** Noble and Taylor
**Mechanical engineer:** Alan Clarke
**Structural engineer:** The Morton Partnership
**Energy consultant:** Arboreal Architecture/Alan Clarke
**Airtightness testing:** Jennings Aldas
**Planting design:** Growth Industry
**Mechanical contractor:** SW Hunt
**Electrical contractor:** Andrews and Hart
**Mineral paints:** Keim Mineral Paints
**Woodwork paint:** Auro
**Cellulose insulation:** Warmcel
**Wood fibre & calcium silicate boards:** Ecological Building Systems
**Vacuum insulated panels:** Kevothermal
**Aerogel insulation:** Thermablok
**iQ Therm:** Remmers
**Perlite beads:** Perlite Silvapor
**Glass foam insulation:** Technopor
**EPS/Styrofoam:** Kingspan
**Purenit:** Puren
**Thermal blocks:** Foamglas
**LED lighting:** Deltalight

[1]Feist, W, EnerPhit: Criteria for Residential-Use Refurbished Buildings, (2010)

[2]Little, Joseph, Breaking the Mould V, Construct Ireland, issue 12, vol 4 (March – April 2010)

## Want to know more?

**Click here to view additional information on these projects, including an online gallery featuring illustrations, photographs, and project overview panels.**

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(Clockwise from above) 30mm Kevothermal vacuum insulated panels were installed over the existing concrete slab; a variety of strategies were used to insulate external walls including Aerogel-backed magnesium silicate boards; 15 Hygrotrac wireless sensors have been inserted into fabric of building to monitor hygrothermal performance.

## PROJECT OVERVIEW:

**Building type:** whole house retrofit of early-Victorian semi-detached house

**Location:** Clapham, London

**Area:** approx 201 sqm (SAP) or 170 sqm (PHPP)

**Completion date:** October 2013

**Space heating demand (PHPP):** 40 kWh/m²/yr

**Heat Load (PHPP):** approx 19W/m²

**Primary Energy Demand (PHPP):** 114 kWh/m²/yr

**Airtightness (at 50 pascals):** 1.8 ACH (co-pressure test)

**Environmental assessment method:** AECB Silver Standard

**EPC rating**
**Before:** E (49)
**After:** D (68)

**Thermal bridges:** 10mm Aerogel at window reveals, 10mm Aerogel at wall returns, Purenit as thermal break for framing and new structural supports, Foamglas Perinsul at new door/window openings.

**Ground floor:** 30mm Kevothermal vacuum insulated panel with Lytag insulating screed over existing concrete slab. U-value: 0.25

**External walls (ambient):** All walls insulated to an average U-value of 0.38. Materials used include Gutex woodfibre, Aerogel and IQ Therm.

**External walls (two-thirds below ground):** All walls insulated to an average U-value of 0.15. Materials used include Foamglas, EPS and XPS.

**Second floor ceiling (cold loft):** 280mm blown cellulose with TGI joist. U-value: 0.15

**Insulation between joists:** 150mm Calsitherm. Average U-value: 0.30

**Windows:** Single-glazed original sash windows with double-glazed secondary glazing. U-value 1.25

**Front & back door:** insulated with 30mm Kevothermal VIPs in panels and 10mm Kevothermal VIPs over. U-value approx 0.9.

**Heating system:** Worcester Bosch Greenstar gas boiler 12i (12kW) and FR110 programmable room thermostat. Hot water cylinder: Worcester Bosch TC-210 (211 litres) with solar thermal control interface. Three square metres of Worcester Bosch Solar Lito Mini solar thermal panels. Stelrad Radical mini radiators with TRVs (controlled flow system with up to 10% energy savings).

**Ventilation:** Vent Axia Lo Carbon Centra Selv mechanical extract ventilation system

**Sustainable materials and fittings:** Keim Ecosil ME photocatalytic, vapour permeable mineral paints, British-grown solid ash timber floor, low energy LED lights throughout, Berbel Eco-switch kitchen extractor.

**Monitoring:** 15 Hygrotrac wireless sensors buried into fabric of building


# *Deep* retrofit

## brings Victorian home up to Enerphit

There was a time when insulating an historic property meant treading lightly on its building fabric. But today, guided by building physics, passive house designers continue to push the boundaries of retrofit by bringing old homes up to modern standards of super-insulation. This project is the third such deep retrofit to an historic London property by Green Tomato Energy.

**Words: Lenny Antonelli**

Plenty of people look to build a new house or upgrade their existing home, but few actively go looking for a run down shell to fix-up. But building a new house in London isn't easy or cheap, and Luigi Caccavale says he and his wife Jane were "looking for something that we could put our mark on".

The couple came across a run-down Victorian house in London SW18, and bought the property with the intention of radically overhauling it. Energy efficiency was a priority, and while Luigi had heard of passive house, he wasn't planning to aim for the standard.

He appointed a contractor (Reality HG) and an architectural design consultant (Richard Bridges), but later decided to bring in Green Tomato Energy as dedicated energy consultants. The company was behind the pioneering renovation of two historic properties at Lena Garden and Princedale Road in London to the passive house standard.

But Luigi still wasn't thinking about passive house. The contractor (who subcontracted out the on-site labour) was keen to get started, but Green Tomato Energy wanted to go back to the drawing board and refine the energy design details.

The company told Luigi about Enerphit, the Passive House Institute's retrofit standard, which was quite new at the time. Luigi decided to halt plans to start work and to begin working through the details again, with the aim of reaching Enerphit.

This would mean heavily insulating the house on the inside of the existing walls. Even though the property isn't in a conservation area, external insulation was a non-runner with the planners. And of course, insulating inside to onerous U-values carries the risk of interstitial condensation (and subsequently mould or structural defects) if the dew point is reached within the wall build-up. Dealing with this challenge required a lot of careful modelling.

"That's where we lost most of the time. And that's where I realised the level of detail that is required," Luigi says. "We haven't gone through

Photos: Joana Saramago / 4C Associates

winter yet, but I think we got it right."

The property is only 5.5m wide, so the team opted to use 100mm Xtratherm Safe R phenolic board to insulate inside the walls. Phenolic provides a high level of insulating performance for less thickness than polystyrene or mineral wool.

The joists of the second floor, however, run from the front to the back of the house rather than between party walls — meaning they penetrate the thermal envelope and leave timber exposed between the insulation and the wall, an area that could be prone to condensation.

The certifier, Peter Warm advised that dynamic hygrothermal simulation - using the Fraunhofer Institute's Wufi 1D and 2D software - should be carried out on this junction. Marine Sanchez, building physics engineer and passive house designer at Green Tomato Energy, explained that the most robust solution would have been to rehang the joists inside the thermal envelope. But this would have involved major structural work, and the budget simply wasn't available.

The second best solution was to ventilate the cavity between the insulation and the old wall, to protect the joists from rotting.

Joseph Little of the Building Life Consultancy analysed this junction using Wufi 1D and 2D, and advised that while this wasn't quite as robust as rehanging the joists, it should keep conditions within the timber joist ends at just under acceptable moisture limits.

Green Tomato Energy also installed eight moisture monitors in the joists ends (four on each façade). If monitoring indicates they are at ▶

risk, the plan is to impregnate the bricks of the external facade to reduce the water content in the bricks and protect the joists. In such instance it would be essential to use a breathable water-repellent product — so that liquid water can't get in, but water vapour from inside can still escape.

The use of Xtratherm Safe-R phenolic insulation was continued through the rest of the building envelope. It was used to insulate the pitched roof of the original house, the flat roofed extension, and the ground floor of both the new and old structures. The team also used Foamglas Perinsul low thermal conductivity blocks around the perimeter of the floor and above the new steel beams now supporting the first floor walls, to cut out thermal bridging.

Xtratherm Safe-R was also used to full-fill the cavity walls of the extension, which are constructed with Thermalite Hi-Strength concrete blocks. Marine says the design of the extension required a lot of modelling to assess and eliminate thermal bridges — or to make sure any that couldn't be eliminated were reduced to a minimum. The complete airtight layer — for both the original house and the extension — is provided by the Pro Clima suite of tapes and membranes.

Keen to maintain the historic facade, Luigi chose to install Green Tomato Energy's own triple-glazed sash-lookalike casement windows, which the company first developed for their passive house retrofits at Lena Gardens and Princedale Road. These feature standard argon-fill and a low-e coating, and deliver an overall U-value of 1.06. For the extension, the windows are triple-glazed Optiwin Alu2Wood units, sourced from the Green Building Store.

Luigi and Jane were also keen to let more natural light into the dark Victorian interior, and chose to install Glazing Vision triple-glazed roof-windows to the extension, which houses the kitchen and dining area.

"One of the issues was poor natural light so we positioned two roof lights, fixed vertical glazing and sliding doors on the side and rear [of the] extension to gain as much natural light as possible as the sun moved around the property throughout the day," says architectural design consultant Richard Bridges. Meanwhile the house's heating system is about as simple as it comes — a Vaillant condensing gas boiler supplying standard radiators on the first and second floor, and underfloor heating on the ground floor. There's also a small wood-burning stove, and a Paul Focus 200 heat recovery ventilation system.

"We needed to find a way to get the cats in and out of the property in an airtight and thermally efficient way"

The final blower door test produced a result of 0.87 air changes per hour, and the house received Enerphit certification in May. But besides energy efficiency, what kind of place to live did Luigi and Jane want to create?

Richard Bridges says: "The first goal was to extend the property on the ground floor to create a more open-plan, free-flowing, light-filled family kitchen, dining and living area more suitable for a modern day growing family."

"We also had to squeeze in a ground floor utility and WC which wasn't present in the original layout. The cats also featured on the main design brief. We needed to find a way to get the cats in and out of the property in an airtight and thermally efficient way!" (The team ended up choosing an airtight cat flap from Freedom Pet Pass).

While Luigi and Jane only moved into the house in April, most of the building work was completed by December, and anecdotally Luigi says that even before the heating system was commissioned it was quite warm inside, with painters wearing just t-shirts while working in the dead of winter. The house has also had to deal with recent heat waves, and Luigi says that as long as he opens windows at night, there is no overheating.

So what lessons have been learned from such an ambitious retrofit? Naturally enough considering how the project started out, client, architectural designer and energy consultant all agree that it would have been best to plan the retrofit in detail from an earlier stage. Luigi says this would have saved him money too, particularly on labour costs.

"It was a very good learning curve for everybody, especially as the rest of the team had never been introduced to Enerphit [before] or anything like that," says Marine. She credits Luigi's commitment to reaching the Enerphit standard for driving the project through. "Without his determination we might not have ended up in the same place."

Richard Bridges adds: "The whole design team, builder and client had to be in the same mind set and completely committed to achieving the end goal from the outset, as all typical construction details for a domestic project of this type had to be modified and thought about in a new way that most people in the team were not used to dealing with."

Putting an ultra-detailed project like this to tender and just picking the cheapest offer will not work, Luigi says. He offers his advice on ▶


(from top) An airtight catflap was installed to give the pets access to the house; this touchscreen panel provides an easy way to control the heat recovery ventilation system; Foamglas Perinsul was installed above the new steel beams now supporting the first floor walls to cut out thermal bridging; 100mm Xtratherm phenolic insulation beneath a 15mm OSB plus Pro Clima tapes airtight layer.

picking a design and building team for a project like this: "Get people that are buying into the objective you want to achieve," he says. "You've got to have a bit of passion, and you've got to have someone who wants to achieve that as well."

**SELECTED PROJECT DETAILS**
**Clients:** Luigi Caccavale
**Passive house consultant:** Green Tomato Energy
**Architectural design consultant:** Alexander Bridges
**Civil & structural engineering:** Elite Designers
**Main contractor:** Reality HG
**Internal & cavity wall, floor & roof insulation:** Xtratherm
**Sash lookalike windows:** Green Tomato Energy
**Extension windows & heat recovery ventilation:** Green Building Store
**Roof windows:** Glazing Vision
**Airtightness products:** Ecological Building Systems
**OSB board:** Smartply
**Thermal Bridges:** Foamglas Perinsul
**Front Door:** Apeer
**Gas boiler:** Vailliant
**Wood burning stove:** Morso

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(above) the triple-glazed rooflights from Glazing Vision allow plenty of natural light into the new extension, which houses the kitchen and dining area; sash look-alike casement windows also feature to maintain the historic facade

## PROJECT OVERVIEW:

**Building type:** 100 sqm terraced Victorian solid brick house plus new 39 sqm metre extension.

**Location:** Wandsworth Borough, London

**Enerphit certification:** certified

**Space heating demand (PHPP)**
**Before:** 225 kWh/$m^2$/yr (estimate)
**After:** 23 kWh/$m^2$/yr

**Heat load (PHPP)**
**Before:** 90 W/$m^2$ (estimate)
**After:** 14 W/$m^2$

**Primary energy demand (PHPP)**
**Before:** 330 kWh/$m^2$/year (estimate)
**After:** 114 kWh/$m^2$/year
**Airtightness (at 50 Pascals, after):** 0.87 ACH

**Thermal bridging:** Foamglas Perinsul used to address structural thermal bridges around solid floor perimeter and above new beams supporting the rear first floor walls

**Existing walls**
**Before:** solid brick walls. U-value: 2.1 (estimate)
**After:** Existing brick walls, followed inside by ventilated cavity, 100mm Xtratherm phenolic insulation, 15mm OSB with Pro Clima airtightness tapes, 12.5mm plasterboard. U-value: 0.17

**Existing roof**
**Before:** uninsulated roof. U-value: 2.5 W/$m^2$K (estimate)
**After:** Roof slates on battens, on 80mm Xtratherm phenolic insulation between existing rafters, on 50mm Xtratherm phenolic insulation below rafters, on 15mm OSB with Pro Clima airtightness tapes, on 12.5mm plasterboard. U-value: 0.19 W/$m^2$K

**Existing floors**
**Before:** uninsulated suspended floor. U-value: 3.0 (estimate)
**After:** 100mm Xtratherm phenolic insulation below existing joists,170mm Xtratherm phenolic insulation between existing joists,–25mm underfloor heating in screed between existing joists,15mm OSB with Pro Clima airtightness tapes over joists, finished with 12.5mm plaster-board. U-value: 0.09

**Windows to existing structure**
**Before:** single-glazed, timber windows and doors. Overall approximate U-value: 3.50
**After:** Green Tomato Energy sash look-alike casement windows. Timber frame window / triple-glazing with two low-e coatings and argon filled with TGI spacer. Overall U-value: 1.06

**Extension walls:** 100mm Thermalite Hi-Strength block, followed inside by 130mm Xtratherm phenolic insulation, 100mm Thermalite Hi-Strength block, 15mm OSB with Pro Clima airtightness tapes, 12.5mm plasterboard. U-value: 0.13

**Extension roof:** Zinc roof coverage on 15mm timber board, on 130mm Xtratherm phenolic insulation, on 100mm Xtratherm phenolic insulation between timber frame, on 15mm OSB with Pro Clima airtightness tapes, on 12.5mm plasterboard. U-value: 0.10

**Extension floor (solid):** 65mm concrete screed on 130mm Xtratherm phenolic insulation, on 150mm reinforced concrete slab. U-value: 0.15

**Extension windows:** Optiwin Alu2Wood windows triple-glazed windows. Overall U-value: 0.77

**Extension roof windows:** Glazing Vision triple-glazed rooflights (Flushglaze range). Overall U-value: 1.09 (in vertical position)

**Front door:** Apper Wood-PU composite door. U-value: 1.01

**Heating system:** Vaillant EcoTEC Plus condensing gas boiler supplying underfloor heating and radiators. Plus standalone Morso 4KW wood burning stove.

**Ventilation**
**Before:** no ventilation system. Reliant on infiltration, chimney and opening of windows for air changes.
**After:** Paul Focus 200 heat recovery ventilation system (PHI certified) – heat recovery rate of 91%.

# HOW TO SAVE

# SOCIAL HOUSING BLOCKS

Britain and Ireland's post-war social housing blocks are seen as ugly and uncomfortable, and suffer from high energy bills, damp and mould. But three ambitious renovation projects show the answer doesn't always lie in demolition.

**Words: Kate de Selincourt**

Britain's post-war house-building boom was all about numbers. The government piled 'em high by funding first tower blocks, then mid- and low-rise blocks. Pre-cast solid concrete was the defining material, system building the defining method.

While indoor bathrooms and central heating were greatly appreciated by new occupants, the post-war dream of urban renewal quickly turned sour for many. Cold bridges and leaks led to condensation and mould, while outside there was sometimes social decline too. Many of these developments have now had a bad reputation for decades. Some have been demolished; others refurbished, but many are still crying out for improvement.

The three retrofit projects presented at a passive house conference, organised by Encraft earlier this summer in Birmingham, exemplify the challenge. Parkview Hub in Thamesmead, Erneley Close in Manchester, and Wilmcote House in Portsmouth are all run-down post-war housing blocks. The first two (where work is already well advanced) are single blocks of four and five stories respectively. Wilmcote House in Portsmouth (where work has just begun) is a lot larger, with 107 dwellings in three linked 11-storey blocks.

All needed extensive repairs due to deteriorating fabric and leaks, and because living conditions were poor and energy bills high. All are now being retrofitted with the aim of achieving Enerphit, the Passive House Institute's retrofit standard.

Erneley Close has both horizontal walkways and vertical piers or "fins": the building is practically made of thermal bridges. Inside, the flats suffered from condensation and black mould. According to passive house designer Eric Parks, they were "amazingly cold and uncomfortable; they managed to be both stuffy and draughty".

The Parkview Hub is owned by Gallions Housing; built from concrete panels, with lots of cold bridges, the windows and doors had already been replaced once but were leaking again. The mastic between the blocks was shrunken and leaking. Heating bills were as high as £40 per week.

Wilmcote House, belonging to Portsmouth City Council, was built from the Bison Reema system of prefabricated concrete panels. The average SAP rating was 55 and flats cost around £25 a week to heat. The storage heaters were hard to control, and the majority of occupants have been living at below recommended temperatures. Leakage and condensation both posed problems, and the flats suffered from damp and mould. Many residents have complained of poor health which some suspect is caused or exacerbated by their living conditions. A vocal residents group has demanded the landlord improves these properties.

The options open to the three landlords were to either demolish and rebuild, carry out a shallow retrofit, or go much further and undertake a deep retrofit.

**Why not demolish?**
Sometimes demolition is the only option, such as when a block is unsafe or otherwise irretrievable, or has acquired such a bad reputation that no-one wants to live there. Even retrofitted, housing blocks may remain unappealing to live in, but if knocked down, they could be replaced with new code four (Code for Sustainable Homes level four) or passive housing. It might also be possible to rebuild low rise blocks at a higher density. And at least you know where you stand with a hole in the ground. With a retrofit, you don't know what you'll find once you start work.

However, it is impossible to knock down and rebuild someone's home without causing major disruption to their life – and their community. There is also lost rent for the landlord when demolishing, and the expense of rehousing tenants.

Furthermore, demolition of social housing often leads to replacement by a mixed development

(opposite) A before and after photo and rendering of Wilmcote House in Portsmouth, which has just broken ground as Passive House Plus goes to print; (this page, clockwise from top) Parkview prior to retrofit; and close to completion; the Gumpp and Maier wall panels arrive on site complete with windows and doors, vent penetrations, insulation, airtight layer; and cladding; an illustration of the building's retrofitted external timber frame; (p75, from top) illustrations and photos of Wilmcote House's façade and walkways as is and as will be; the original façade replete with cold bridges

in which the number of social rented units is diminished, meaning some social tenants cannot move back in, and the new units for sale may cost a lot more than prices paid to any displaced leaseholders – a trend criticised as 'social cleansing'. If the landlord opts for retrofit, planning permission is likely to be much less of an issue. In fact, planners may well welcome the transformation.

Refurbishment also generally gives rise to much fewer carbon emissions than demolition and rebuilding – and when renovation is to the Enerphit standard, there is little danger of these emissions savings being outweighed by in-use energy consumption in the property.

**But why go so deep?**
The three reasons given most often by social landlords for aiming for Enerphit are: tackling fuel poverty, protecting their estate (and reducing maintenance), and the desire for quality assurance. Carbon reduction is not often mentioned. This may well be because fuel poverty is more pressing — however, it is also the case that actual carbon reductions from retrofit are hard to predict when people are currently under-heating their homes.

Social landlords want to tackle fuel poverty for the welfare of their tenants, but also because low-income tenants living in cold dwellings and struggling with bills are more likely to suffer damp and mould — which damages the property and leads to call-outs, maintenance costs and even lawsuits — and to have less money left over for rent.

Many landlords are concluding that standard low energy retrofits don't really protect residents from fuel poverty, while new homes built to or above code level four are relatively warm and affordable to heat. Enerphit squares that circle, and offers a chance to match and even exceed code four level of performance.

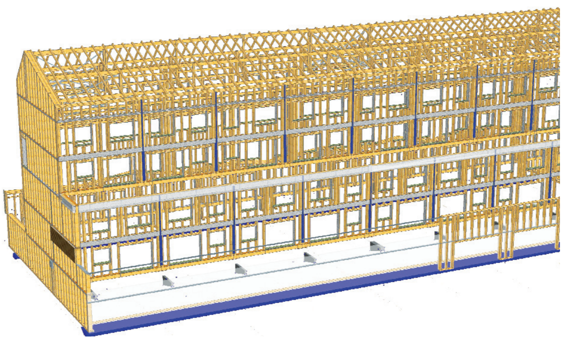
The retrofit of Parkview in Thamesmead is pioneering the use of off-site construction to deliver accurate high-performance construction, minimising time and mess on site. Insulated facade panels complete with factory-installed windows and pre-fixed cladding came to the site and were bolted to the outside in a matter of days. Modelling indicates the retrofit should deliver an 85-90% cut in heat demand.

At Wilmcote House, according to the project architects ECD, achievement of Enerphit will cut heating and hot water costs by 90%, saving around £750 per dwelling each year. Comprehensive retrofit does a lot more than simply tackle energy bills, though. At Wilmcote, the plan is to wrap the entire building in external wall insulation and glazing to cut thermal bridging. Glazing the balconies and walkways should also make them safer, something residents had requested, and will also give each flat a sun room that can be used to dry clothes. (A similar strategy at Parkview has also created extra internal space.)

Steve Groves of Portsmouth City Council said a major motivation for Enerphit was to save on future costs. Having logged maintenance call-outs and expenditure for many years, the council will be in a good position to compare before and after scenarios, even for individual items such as window repairs (previously 80% of Wilmcote House residents requested window repairs over just two years) or redecoration for condensation.

The council also hopes that by achieving Enerphit, the upgraded homes will perform well enough to ease the relationships between landlord and tenant, and between tenants, their homes, and their wellbeing: "There is an issue where tenants don't want to use central heating and extract fans because of the expense. If their homes are upgraded to give a really good standard of performance, we believe this will reduce the desire of tenants to switch off these important services," Groves said.

**Practical challenges**
Of course Enerphit means installing MVHR, and this is never straightforward for a retrofit. However it isn't insurmountable. At Parkview Hub it was possible to take advantage of disused air heating risers to accommodate ductwork, and the fan units are being located in new space created by the retrofit. At Erneley Close the fan unit is in the bathrooms, and the ducting mainly ▶



runs though the existing services zone, plus some boxing in.

You might think that externally insulating rectilinear concrete blocks of repeating units would be relatively straightforward — but of course it isn't. For one thing, these blocks are almost never a simple shape, thanks to the walkways and balconies. Uninsulated, these structures have a disastrous effect on thermal performance. Erneley Close superficially has a surface-to-floor-area ratio of around two – until you take into account the walkways and structural piers, which drive it up to around three.

Here the team opted to wrap insulation all over the top and bottom of walkways and fins – which involved fixing new handrails and incorporating a drainage channel without penetrating the insulation.

Even insulated, the walkways and piers still exhibit heat loss: "We are now at stage where the fabric is really high-performance, and perhaps one third of the losses are down to thermal bridges — there's just so much total length that they still make a big impact, " Eric Parks explained.

preparation before the works begin, perhaps offering the most vulnerable the opportunity to move; better communication of the nature of the project and its energy saving potential; and making staff available to listen to residents' concerns.

Experience on the more advanced of the Enerphit retrofits backs this up. At Parkview Hub, Martin Montgomery of contractor Gumpp and Maier says, things that might seem small caused great concern to occupants, but once the landlord met the residents, solutions could be found.

"The biggest single issue was probably the fact that to fit the cladding, all the TV dishes had to be removed, and people were really worried about this. However it was not that expensive simply to replace them with a communal TV subscription. Similarly, people were very concerned about their decor being damaged: yet they were happy to accept DIY vouchers, enabling everyone to take care of their own repairs."

At Wilmcote, where work is just beginning, the team report that at the last consultation resi-

## Some health authorities are already investing in improvements to the housing of their more vulnerable patients to cut treatment costs and reduce expensive hospital admissions

At Parkview and Wilmcote the designers opted to glaze in the walkways. While this solves some problems, it may cause others. At Wilmcote the kitchen windows open on to the walkways. Most of us use purge ventilation via a window when we burn the toast, but after the walkways are glazed in, the windows will no longer be openable, because they face a fire escape route. Project advisors Encraft are now considering whether to install dedicated extract fans for more ventilation.

To investigate this they are taking advantage of a vacant dwelling where solutions can be tested. This empty unit is being retrofitted, complete with a working kitchen in which test meals will be cooked, to refine the ventilation design.

**Resident disruption**

The chances are most current occupants of blocks undergoing deep retrofit will be keen for their homes to be improved. However they may not be prepared for the reality of the intrusive works required. Retrofit with occupants in situ is usually hardest for people on night shifts, and those who are elderly, unwell or housebound, or have young children. Noise and dust are generally the main concerns.

It's a lot easier for people to cope if they understand what will happen during the retrofit, and why. One resident at ECD's previous deep retrofit in West London, who understood the retrofit would tackle her appalling draft problem, was philosophical: The noise was "hell" she said, "but even if you renovated Buckingham Palace you'd still have the noise. There's no such thing as a rubber drill."

The report on these residents' experiences made the following recommendations: better advance

dents were 98% supportive of the scheme, with 78% of residents attending the session. With the opportunity to refine the approach by practicing in the vacant units, the idea is for the operation to be as slick as possible once they move on to occupied units: "The contractor has been allowed just six weeks access per flat," says Encraft's Helen Brown.

Sadly the best intentions to work with residents in situ can come unstuck. At Erneley Close the construction team found that, despite investigations at the start, many of the wall panels to which they intended to fix external insulation were in such poor condition that they had to be replaced with insulated timber panels instead – plus, the heating systems had to be removed, so the occupants did have to move out for a while.

**Will it be worth it?**

A new build to level four of the Code for Sustainable Homes could cost around £1,000 to £1,500 per square metre. New-build passive house dwellings may cost a little more – recent analysis has suggested prices of £1,400 to £1,600.

If the landlord has a choice between rebuilding and retrofit, this can leave quite a generous budget for retrofit – especially if the refurbishment can be completed without moving the occupants out and losing rent. While the Parkview Hub retrofit is now quoted as costing £1,114 per square metre (a figure that includes some newly built accommodation too) it has to be remembered that achieving code four has been honed in price over a number of years, while Enerphit is still very new.

The Wilmcote House retrofit is going ahead on the basis that it would be cheaper than rebuilding the same number of units to code four ▶

and paying the associated costs such as lost rent. At Erneley Close, according to developer R-Gen, the costs of the Enerphit aspects of the work are estimated at around £1,000 per square metre.

But given that Enerphit is so demanding, does it make sense to go this deep? Some eyebrows have been raised at the cost. One point often made is that the payback time in terms of energy savings is much longer for a full Enerphit than for selected interventions such as roof insulation.

However, as Dr Diana Ürge-Vorsatz, director of the Center for Climate Change and Sustainable Energy Policies at Central European University, argued at the 2014 International Passive House Conference, a shallow retrofit today locks out the possibility of a deeper retrofit for years, even decades, to come. This is catastrophic for tackling climate change. And if you're going to the trouble of designing a refurbishment, securing finance, and making the occupants' life a misery, why wouldn't you do as thorough a job as you can, now?

“Going to Enerphit will incur extra costs above simply upgrading to the current building regulations, but it should future-proof our stock,” explained Steve Groves of Portsmouth City Council. “A refurbishment like this is expected to last 30 years, and over that 30 years it will have to cope with changes in government standards and targets – who knows what the next 30 years will bring?

“We are hoping that by doing as much as we can now, we will be one step ahead and won’t be in a position where requirements change but we can’t react across the whole lot of our stock quickly enough.”

David Williams, deputy chief executive of Erneley Close’s owners, Eastland Homes, admits that upgrading to Enerphit is expensive. However he says it makes sense from a social and financial point of view: “The residents in the maisonettes are the poorest people in our housing stock, and we would have had to have done considerable work to get the homes up to Decent Homes standard anyway.” His team partner Phil Summers, director at R-Gen, agrees: “The world has moved on since Decent Homes was the standard to aspire to.”

**PROJECT CREDITS**

**Erneley Close**
**Client:** Eastland Housing
**Architect:** 2e Architects
**Developer:** R-Gen
**Contractor:** Casey
**Passive house designer:** Eric Parks

**Parkview Hub**
**Client:** Gallions Housing (part of Peabody Group)
**Architect:** Sustainable By Design
**Contractor:** Gumpp & Maier
**Passive house consultants:** Chiel Boonstra of Trecodome
**Feasibility study:** ECD Architects

**Wilmcote House**
**Client:** Portsmouth City Council
**Architect:** ECD Architects
**Contractor:** Keepmoat
**Lead designer for contractor:** Sustainable by Design
**Passive house consultants:** ECD (client), Encraft (contractor)

(from top) Erneley Close prior to upgrade work commencing; the careful application of external insulation begins; high performance insulation fitted at door thresholds to minimise cold bridging; taping for windtightness; insulated timber panels were used to cover much of the building’s façade

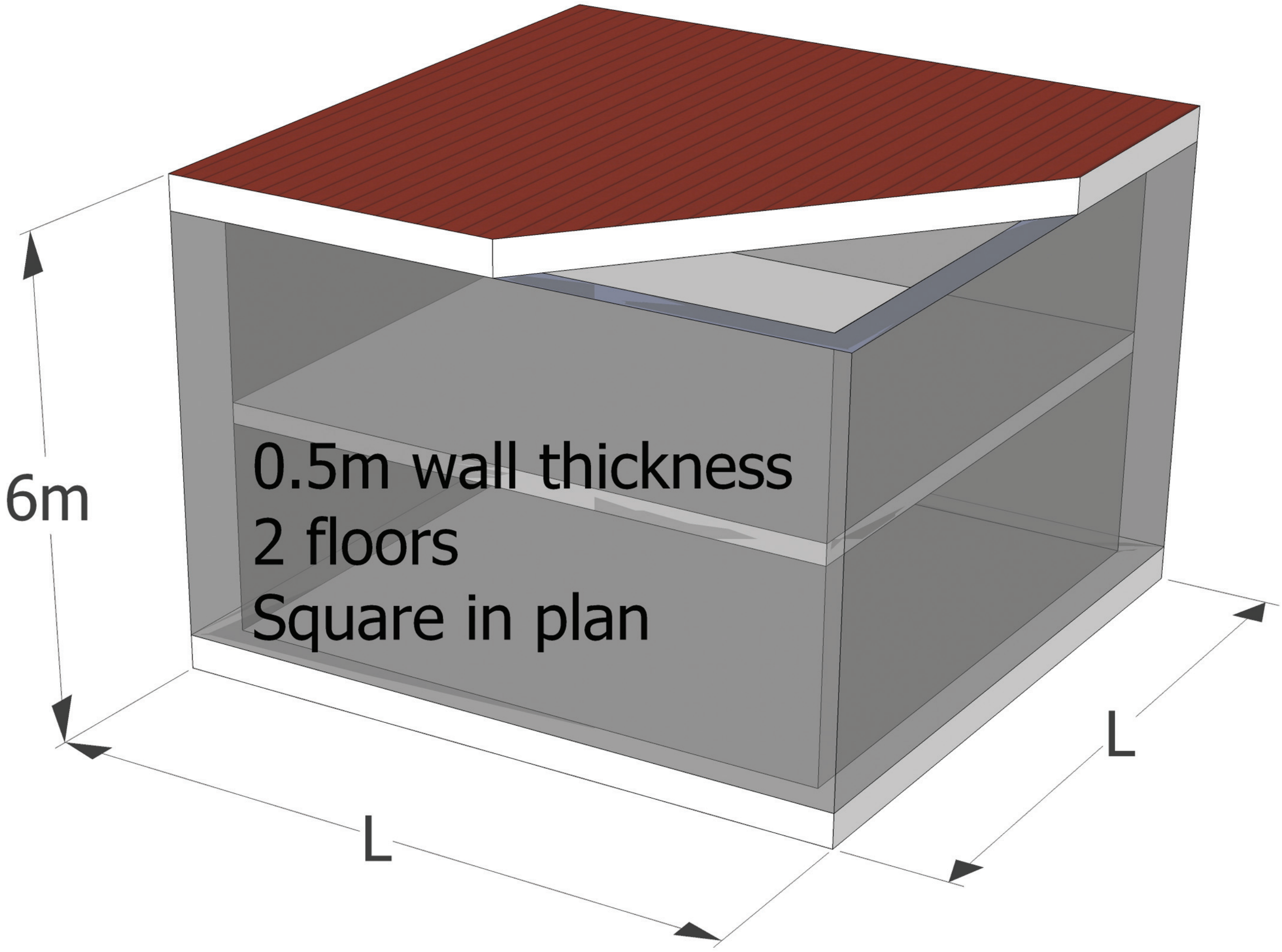
## Retrofit and health – some joined-up action at last?

**The benefits of retrofit go beyond energy bills, and indeed, beyond those who occupy and own the buildings. A recent UK Green Building Council report notes that the calculated annual cost to the NHS in England of cold homes is £1.36 billion, as well as the associated social care costs. They estimate that, for example, insulation of all solid walls in the UK would give health improvements equivalent to £3.5bn to £5bn over the lifetime of the measures.**

**Some health authorities are already investing in improvements to the housing of their more vulnerable patients, for example by funding new boilers and insulation in patients’ homes, in a bid to improve people’s health and quality of life, cut treatment costs and reduce expensive hospital admissions. The UK’s National Institute for Health and Care Excellence is currently developing advice to clinical commissioning groups on reducing excess winter deaths and illnesses – including advice on promoting retrofit.**

**Though the wider social benefits are harder to quantify than simple energy payback calculations, they are just as important, and are taken very seriously. Three universities, plus the BRE and the Europe-wide Europhit programme, are studying how the Wilmcote House retrofit affects the lives of residents, looking not just at energy and comfort, but also health and wellbeing. As well as the tenants, the research will involve neighbouring health centres and schools to get a rounded view of whether the whole process has been worthwhile. The results will be important reading. Wilmcote House is probably the most wide-ranging, but all three projects have formal research programmes.**

**Other social landlords – and indeed local authorities and even health bodies — will be looking closely at the results. It will be on much wider issues than just energy performance and build costs that the success of these Enerphit projects should be judged.**

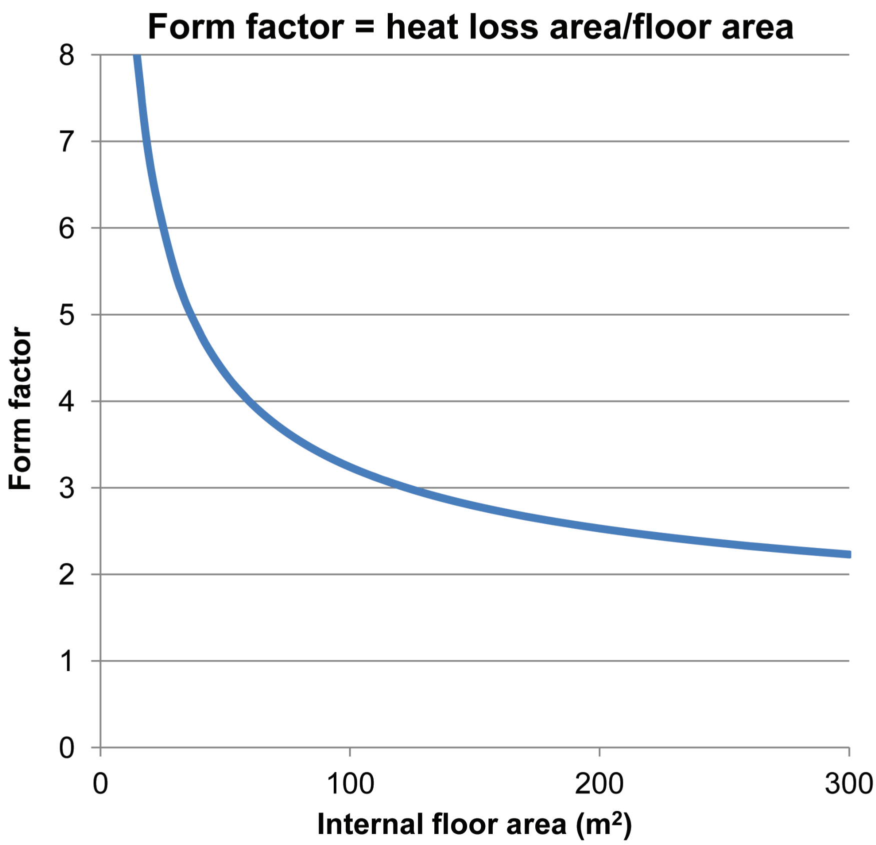



# THE SMALL PASSIVE HOUSE PROBLEM: *a solution?*

It's sometimes said to be hard – perhaps too hard – to get a small house to meet the passive house standard. But a small house will have small heating bills, so why is it hard for a small house to be a passive house? Leading passive house consultants **Alan Clarke** and **Nick Grant** delve into the passive house software to find out what's going on.

To be certified as a passive house a dwelling needs to demonstrate compliance with the standard in the PHPP energy model. The rigor of this model is key to the success of passive house in delivering buildings with heating demand as low as promised. There are a number of ways that passive house has closed the "performance gap"– including detailed thermal analysis of junctions and windows, and a high standard of on-site quality assurance – but another factor is the use of conservative estimates for internal heat gains.

Traditional energy models have tended to try and emulate the average performance of existing built stock, so in the UK the Sap model includes typical appliance[1] and lighting energy use, and a generous allowance for heat loss from hot water systems. Whilst these assumptions ensured hot water and lighting energy use weren't underestimated, they were then fed into the thermal model as heat sources, and, with a good wodge of insulation, the model showed that a well-insulated house might not need any heating




(Opposite and above) The form factor of square buildings. Here the houses are all equally compact, given the square floor plans – but inevitably larger houses have a smaller form factor.

at all.

In practice new houses tend to have the most efficient appliances, and highest standard of hot water cylinder insulation, and this was one factor in the tendency for such houses to have much higher heating bills than predicted.

To counter this, PHPP assumes a level of internal heat gains reflecting the most efficient appliances – as you'd hope to find in a genuinely low energy house. It also allows for hidden losses – evaporation from towels needs heat, cold water in WC cisterns also absorbs heat. (Hot water system losses are counted in PHPP as if they were part of the heating system, so that the design of hot water system doesn't give you any leeway in specifying the building insulation levels.) Combining these gains and losses resulted in a fixed internal gains figure of 2.1 $W/m^2$, as a continuous average – so a 100 sqm house is assumed to have a continuous 210 watts of internal heat gain when averaged across the heating season. In Sap the figure would be 3 times that, which is enough to make a house designed to passive house look like it has no heating demand at all[2].

In fact passive house buildings do have heating demand, and it seems that the PHPP internal heat gains figure is a good approximation in most cases.

However we recently came to help design a retirement bungalow for a couple, to be built in the garden of their existing house. Planning permission didn't allow this to be sold separately so there was no incentive to build bigger than necessary – nor was there the money.

The house was a bungalow of 45 sqm with ideal orientation and southerly aspect – but with passive house insulation, windows and MVHR the heating demand was coming out in PHPP at around $40kWh/m^2/a$, to the disappointment of the client. Surely we can make that a passive house, we thought – and on paper we managed – extra insulation, better airtightness, lower eaves, but crucially we also had to factor in a lot more south facing glazing. We concluded that really, this wasn't a good idea. When we looked at what the heat gain would be from our two occupants, their cooking and washing, and their modest low energy TV and fridge, it was clear that the place would overheat all year round. Our advice was that the passive house standard was the wrong standard for this size of house.

As passive house designers this troubled us – obviously we would like to be recommending passive house as the preferred solution for all sizes of house. We realised there must be an error in how PHPP treated small dwellings and wanted to find out what it was, and how to fix it.

One problem familiar to passive house designers is the form factor of small buildings. Basic geometry shows that a small building has a higher external area per square meter of floor area than a larger building, and so the heat loss per sqm of floor area is also higher (though the total heat loss is of course lower).

But another issue was the internal heat gain assumptions –two people in a 45 sqm house at standard occupancy would provide an average of 2 $W/m^2$ just with body heat. In fact since they'd mostly be at home during the day the gains could easily be 3 $W/m^2$, which is more than the standard assumption for total gains in PHPP before we even consider appliances, cooking and so forth. But this ultra small house might be an extreme case, so for the basis of a paper presented to the 2014 International Passive House Conference in Aachen we carried out a general analysis of the internal heat gain assumptions in passive house design[3].

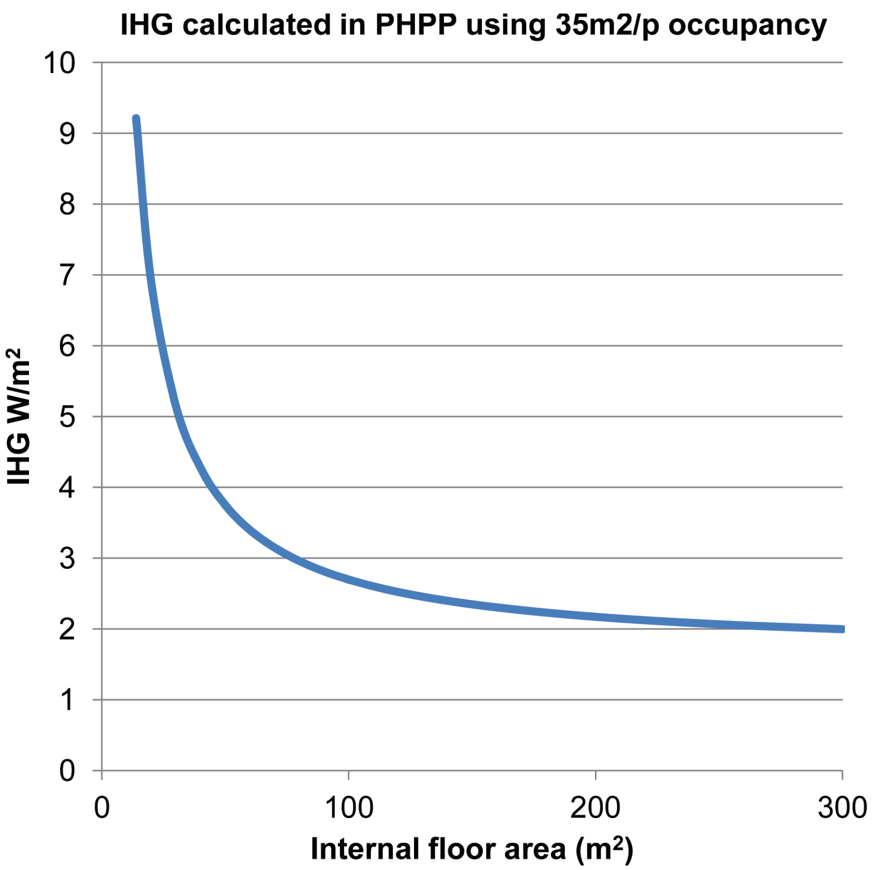
Although PHPP has the standard figure of 2.1 $W/m^2$ for internal heat gains for certification purposes, it also allows you to model "actual" internal heat gains depending on the selection of particular appliances, lighting, consumer electronics, heating pumps etc. (this can be important for summer overheating prediction). For this calculation PHPP also allows the number of occupants to be varied from the default $35m^2$/person figure assumed for certification. So we looked at how the internal gains were built up and found the following:

-There's a basic, fixed, internal gain per dwelling – think of fridges and freezers, and things like heating controls.

-And then there's a heat gain which is taken to be proportional to the number of occupants – laundry, dishwashing, and also cooking, TV etc, and lighting.
-Finally PHPP actually assumes very little heat gain is directly related to floor area – just the pump power for the heating system (though we think lighting energy is in part dependent on floor area too).

So how does PHPP get to a fixed internal gain figure of 2.1 $W/m^2$? Firstly one has to assume that the number of occupants is determined by the floor area – PHPP needs a method that works for a house without knowing how many people will live there – and when we assume one person ▶

New houses tend to have the most efficient appliances, and highest standard of hot water cylinder insulation, and such houses tend to have much higher heating bills than predicted.




per 35 sqm the occupant dependent gains come out at about 1.5 W/m². Then for a house of around 150 sqm the fixed gains make up the remainder and 2.1 W/m² looks like a good figure.

But we looked at how the internal heat gain/m² varied according to house size, when considered as a combination of the fixed gains (such as that fridge) and the variable ones (how many people) as estimated in the PHPP "actual" gains model.

What is interesting is that the curve looks quite similar to the form factor one: small houses have high heat loss per sqm but they also have high internal gains per sqm. Could these two variables cancel each other out?

Next we looked at the assumptions of occupancy. In fact we've seen a whole range of different occupant densities in passive house dwellings – a family of four in an 80 sqm house, or a couple in a 160 sqm house – overall the range we saw was from 20m²/person to 140m²/person. We don't know if our experience is representative, but in any event it's impossible to predict how many people will really live in a house of a given size. However the model needs a  figure for occupancy to base calculations on, so PHPP takes the simplest possible option – a flat rate of 35m²/person. We knew that SAP had a more nuanced approach, but when we plugged the SAP formula into our spreadsheet we thought we'd made a mistake – the total occupancy seemed to top out at about three people per house, however big the house. In fact this formula was carefully considered and reflects the reality of the housing stock based on surveys of 32,000 households: although the smallest dwellings (flats, usually) can only fit one or two people, any larger and the occupancy is basically one family unit – averaging about three people.

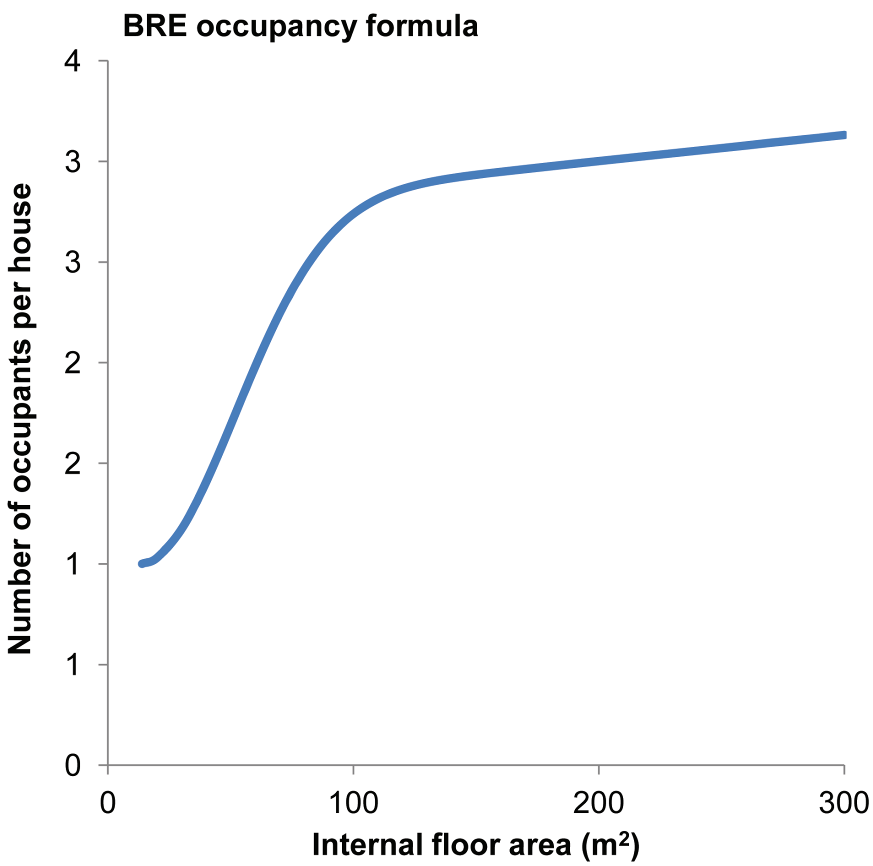
We used this empirically derived formula for occupancy in the PHPP "actual" internal heat gains calculation, and modelled the heating demand of a simple house across a wide range of floor areas with fixed U-values.

Remarkably the curve came out almost flat – whatever size house we looked at, with size-sensitive internal heat gains, and using "passive house components" the annual heating demand was around 15kWh/m²/a  This included larger houses which were showing a result of less than 15 kWh/m²/a heating demand when assessed with the standard 2.1 W/m² internal heat gains figure.

Of course we don't want to be working out exactly which model of fridge we can fit this year, or worrying whether UK housing occupancy is different than in other countries (not much, it turns out according to the data), so we came up with the simplest curve fit we could – an easy-to-use equation of internal heat gains = 71x(floor area)-0.73 W/m². The two variables can be tweaked a bit, this was the best fit for default PHPP electrical use assumptions for floor areas up to 200 sqm. In fact these assumptions have no allowance for all the little always-on loads in a house– controls, smoke alarms, modem, and numerous items on one watt standby – these typically add to up 40-50W but even with the best practice we can't get this below 20W. Including this small addition shifts the curve slightly to IHG = 86x(floor area)-0.75 W/m², which we think reflects reality pretty well. Clearly one could spend plenty of time arguing the finer points of minimising household power use, but this basic equation gives the general shape.

So that's great we think, problem solved. But what if only one person lives in a 90m² house, not the average 2.6 (the same according to SAP and PHPP)? Will they be too cold, or suffer from excessive heating bills? In fact the base heat gain from running a one-person household – the fridge/freezer, modem, smoke alarm, controls, standby loads predominate, accounting for the majority.

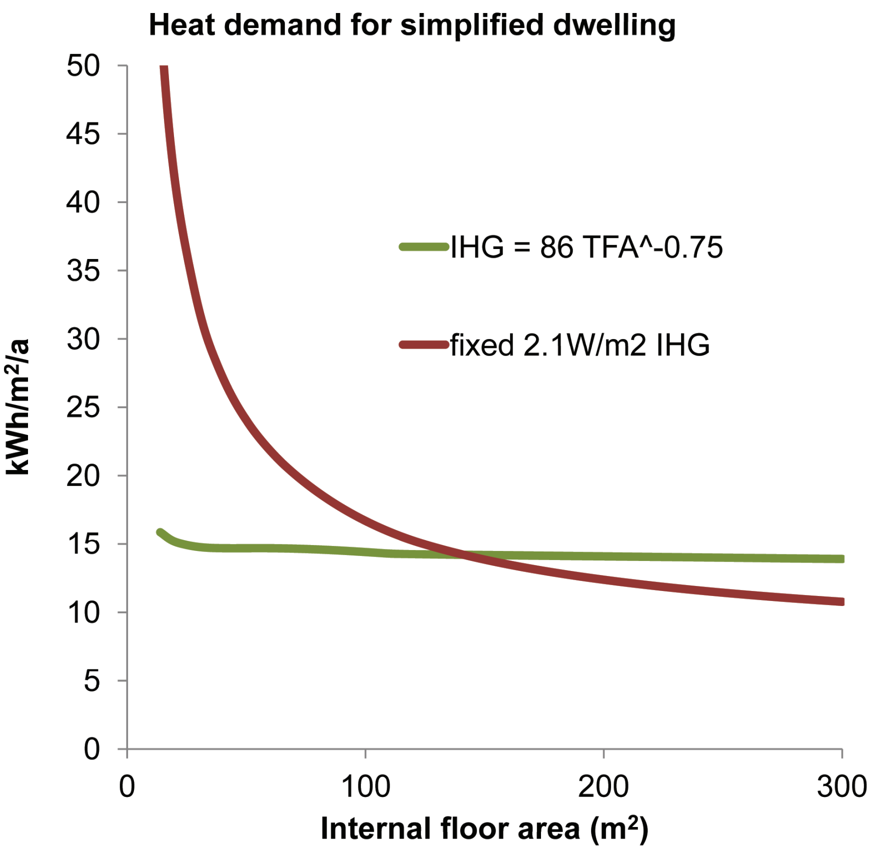
And then what happens if electrical efficiency improves further, as we hope it will – 5W LED bulbs light a whole room, fridges and hot water cylinders have vacuum insulation, and every appliance has a zero-watt standby consumption? Body heat already makes up a useful fraction of the internal gains, so that shouldn't disappear, and if our annual electricity bills are halved at the expense of a small increase



in heating demand then that should be an acceptable price to pay.

Going back to our little 45 sqm house, with our new equation we now assume the internal heat gains will be 4.5 W/m² instead of 2.1. How will that fare if the gains aren't as high as our initial assumptions? With just one occupant, eating a raw food diet straight from the garden, the house may have lost 2 W/m² of internal heat gains but spread over just 45m² that's only a 90 watts shortfall – just a few hundred kWh over the heating season. What looks like a big deficit per square metre is not so bad when the number of square metres is very low.

The basics of passive house are more constant than we thought – 300mm of insulation, triple-glazing, MVHR, compact form, thermal bridge-free & airtight.




Graph showing heating demand for IHG = 86x(floor area)-0.75 W/m² compared with IHG = 2.1 W/m²

So this is our simple proposal – a new equation for estimating the internal heat gains in PHPP when designing a passive house. It happens to solve the "small house problem" but that doesn't mean it's a cheat – it's just a happy consequence of looking more carefully at the model, and at reality. What is really interesting though is that this new model shows that the basics of building a passive house dwelling are more constant than we thought – 300mm of insulation, triple-glazing, MVHR, built with a compact form, thermal bridge-free and airtight, of course.

But note that given the use and occupancy of any individual dwelling is so variable, we do not propose that we base the internal heat gains on actual appliance energy use, but instead recognise that the make-up of household energy use and occupant density leads to a trend for internal heat gains to follow a non linear pattern with respect to dwelling size. By using a simple formula which matches this trend for the average occupancy rate we can maintain the existing passive house fabric efficiency requirements of the standard in medium size dwellings and also resolve the conundrum of how to make passive houses smaller, and hence lower energy consumers, without needing abnormally high fabric standards. A complicated problem has quite a simple solution.

[1]Ed. – This differs from the Irish national methodology, Deap, which doesn't count energy used by appliances. Ironically Deap was designed based on Sap, which originally didn't include appliance use, but was extended to include appliances in 2007 in preparation for HM Treasury's Stamp duty land tax relief for new zero carbon homes.

[2]AECB 2008, A comparison of the passive house Planning Package (PHPP) & SAP. Clarke & Reason http://tinyurl.com/nbdpgf3

[3]Clarke & Grant 2014, Internal Heat Gain Assumptions in PHPP. Proceedings of the International Passive House Conference Aachen 2014. http://tinyurl.com/nwfaszc

## Small houses and heat load

**PHPP aficionados will now be asking: how does this internal gains formula affect heat load (the 10W/m² alternative certification criterion) and the functional definition of passive house (the ability to heat with the ventilation air)? We decided to look at this in our simplified model. The internal gains assumptions for this case exclude those associated with occupancy – with a minimal heating system (such as air heating) you need to be able to keep the house warm when away on a winter holiday, because otherwise it will take too long to bring the house up to a comfortable temperature.**

**The standard internal gains figure in PHPP reflects this, being lower at 1.6 W/m². We realised we could easily modify our model to work out the size dependent gains for an unoccupied house by simply taking the fixed gains, and omitting the occupancy dependent ones – the refrigeration, and standby loads stay, whereas the cooking, washing, lighting go, as do the losses from incoming cold water and evaporation.**

**Our analysis didn't take detailed account of the design weather conditions or solar gain – but as you would expect, the higher internal gains per square metre again counteract the higher heat loss per square metre of floor, though in this "worst case" of lowest gains and highest losses (an empty house over the coldest days of the year) larger dwellings do tend to benefit more from their better form factor.**

**Interestingly when we look at the "functional definition" and include the heat transportable by the ventilation air – with ventilation rate calculated to suit the realistic average occupancy levels according to the BRE's research – we see a different picture. Small houses tend to be more densely occupied so our ventilation rate is above 0.4 air changes per hour for dwellings smaller than 60 sqm. For those larger than 120 sqm the rate is determined by the 0.3 air changes per hour backstop ventilation rate rather than the number of people living in the house. This means that the heat input per metre square from the ventilation air is higher in a small house than a large one, more than making up for the heat load disadvantage.**

**Now we see that it is really quite easy to build a small passive house according to the functional definition, but rather harder to build a large one.**

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